US-APWRRAIsPEm Resource

From: Ciocco, Jeff
Sent: Tuesday, June 12, 2012 12:56 PM
To: us-apwr-rai@mhi.co.jp; US-APWRRAIsPEm Resource
Cc: Jain, Bhagwat; Shams, Mohamed; Galvin, Dennis; Hamzehee, Hossein
Subject: US-APWR Design Certification Application RAI 969-6334 (3.7.1)
Attachments: US-APWR DC RAI 939 SEB1 6334.pdf

MHI,

The attachment contains the subject request for additional information (RAI). This RAI was sent to you in draft form. Your licensing review schedule assumes technically correct and complete responses within 30 days of receipt of RAIs.

Please submit your RAI response to the NRC Document Control Desk.

Thank you,

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REQUEST FOR ADDITIONAL INFORMATION 939-6334 REVISION 3

6/12/2012

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

SRP Section: 03.07.01 - Seismic Design Parameters
Application Section: 3.7.1

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

03.07.01-34

In its response to RAI 850-6002, Question No. 03.07.01-25, the applicant in its justification of the artificial ground motion time history that matched only a single-damping target spectrum, presented comparisons between the CSDRS spectra with the spectra generated from the artificial time histories for three component directions, for 0.5%, 2%, 5%, 7%, and 10% damping. The staff noticed that the 0.5% and 2% damping response spectrum (on pages 3.7-16 through 21) generated from the artificial time histories is not bounded by the 0.9 to 1.3 band which is specified in SRP 3.7.1.
Additionally, the applicant stated in its response that, “The re-generated time histories for the US-APWR are generated in accordance with the guidance of Option I, Approach 2 of SRP 3.7.1 (R3). Unlike the guidance for Option 1, Approach 1; Option 1, Approach 2 only requires enveloping of the computed 5% damping response spectrum of the accelerogram (see items ii.c and ii.d of the SRP).”
The staff noted that the last paragraph of SRP 3.7.1 Option 1, Approach 2 (Page 3.7.1-12) states, “Artificial ground motion time histories defined as described above shall have characteristics consistent with characteristic values for the magnitude and distance of the appropriate controlling events defined for the uniform hazard response spectrum (UHRS).” The technical basis for SRP 3.7.1 Option 1, Approach 2 is provided in NUREG/CR-6728 that was developed to provide guidance on generating time histories for site specific hazard- and risk-consistent ground motion spectra.
In Section 3.7.1.1 of the USAPWR DCD (R3), the site-independent CSDRS is specified as a modified RG 1.60 spectra and not an UHRS spectrum. Therefore, the use of SRP 3.7.1 Option 1, Approach 2 in generating the artificial time history for the site-independent CSDRS is not appropriate.
The staff requests the applicant to develop the design basis synthetic time histories for all three directions of the CSDRS in the DCD (R3), that satisfy the spectral matching criteria and PSD matching criteria of the SRP 3.7.1, Option 1, Approach 1.

03.07.01-35

In its response to RAI 850-6002, Question No. 03.07.01-22, the applicant provides Table 1 which is taken from a source of standard statistical tables. Table 1 shows the sample size required for a given percent error in the standard deviation for a normal distribution, which the applicant purports to support their assertion that using 30 realizations in the analyses provides sufficient stable estimates of means and standard deviations. Further, the applicant states that increasing the sample size to 60 realizations reflects, at best, only an unnecessary and marginal improvement.

The staff considers that the evidence provided in Table 1 to be inadequate for supporting the applicant's argument. The staff is requesting that the applicant use actual data generated from the soil profiles in the US-APWR DCD; provide a table that shows conclusively the convergence as the number of realizations is increased; and provide the rationale to support the claim that 30 realizations instead of 60 realizations as specified in RG. 1.208 is adequate for the analyses.

03.07.01-36

In its response to RAI 850-6002, Question 03.07.01-23, the applicant states that, "Although the most representative earthquake for the CSDRS is a M 7.5, the use of a seed time histories from a smaller event for use in the SSI analyses is not an issue. The key requirement as described in SRP 3.7.1 (Reference 1) is that the 5 - 75% duration requirement be met in generating the CSDRS compatible ground motion artificial time histories."

The values of the 5-75% duration for the CSDRS compatible ground motion time histories are listed in Table 5.1-3 of MUAP-10001 (R3) (Page 5-10) which are 7.52 seconds and 7.145 seconds for the two horizontal components and 8.77 seconds for the vertical component, respectively. Also listed in Table 5.1-3 is the minimum duration of seven (7) seconds taken from Table 2.3-1 of ASCE 4-98. The staff has not reviewed and endorsed Table 2.3-1 of ASCE 4-98. Therefore, the applicant is requested to delete any reference and values from the referenced ASCE Table 2.3-1.

03.07.01-37

In its response to item (i) of RAI 850-6002, Question 03.07.01-27, the applicant states that the equivalent linear random vibration theory (RVT) approach was used to compute strain compatible properties as input to the SSI analyses. The staff noticed that the CSDRS compatible ground motion time histories generated in Section 5.1 of MUAP-10001 (R3) were not used in the site response analyses; instead, the equivalent RVT approach was used. The staff considers this approach to be inconsistent because the time histories generated in Section 5.1 which are used in the SSI analyses, pass through the soil columns that are not excited by these time histories. The applicant is requested to provide data to show that the nonlinearity of soil obtained by the RVT approach is comparable to that induced by the time histories generated in Section 5.1.

Also, the staff did not find any description of the power spectral density function used in the RVT approach described in the report. The applicant is requested to provide a description for the power spectral density function used. In addition, the applicant is requested to compare the computed power spectral density functions at the rock outcrop with those of the CSDRS response spectra for both the horizontal and vertical directions. The comparisons should be presented in graphical form.

In Section 5.2.1 of MUAP-10001(R3), the applicant states that, "Distances are adjusted such that the median spectrum computed for each profile approaches does not exceed the horizontal and vertical CSDRS." The applicant is requested to provide technical information explaining why "does not exceed" is imposed instead of "matching" when comparing the response spectra.

03.07.01-38

In its response to RAI 850-6002, Question 03.07.01-28, the applicant states, in part, that "The vertical CSDRS (Figure 5.2-4) reflects extremely conservative levels of motion and is inconsistent with current observations as well as the community understanding of strong ground motions."

The staff finds that there is evidence that the influence of high water table level, as well as the degree of ground saturation, can have very significant influence on the seismic response, especially in the higher frequencies. For example, in Yang and Sato (2000 a,b), the authors point out that, in measurement in a borehole array during the 1995 Hyogo-ken Nanbu (Kyoto) earthquake, "the vertical motions were greatly amplified at the surface, with peak value of 556 cm/sec^2, which was about 1.5 to 2.0 times larger than the horizontal components." Further, in that same paper, the authors state that "Vertical-component motions may be significantly affected by the pore-water saturation of shallow soil layers, suggesting that we may need to carefully examine the condition of saturation in the study of vertical site amplification." These papers indicate that the water table at the grade level with the soil fully saturated may not be the critical case concerning the vertical motions.

The applicant is requested to clarify and confirm that for the soil profiles considered in the US-APWR standard design, the effects on the vertical seismic response component resulting from varying levels of the groundwater, including the degree of groundwater saturation, have been explicitly considered in the design basis seismic analysis. In particular, the applicant is requested to confirm that these effects will not result in significant increase of the vertical component of ground shaking, and that the US-APWR design remains conservative.

References:

Yang, J. and T. Sato (2000a),"Interpretation of Seismic Vertical Amplification Observed at an Array Site," Bulletin of the Seismological Society of America, 90, 2, p. 275-286.

Yang, J. and T. Sato (2000b), "Effects of Pore-water Saturation on Seismic Reflection and Transmission from a Boundary of Porous Soils," Bulletin of the Seismological Society of America, 90, 5, p. 1313-1317.

03.07.01-39

1. In the response to item 1 of RAI 850-6002, Question 03.07.01-30, the applicant refers to the response to RAI 850-6002, Question 03.07.01-22. In its evaluation for RAI 850-6002, Question 03.07.01-22, the staff considers the applicant's response to be not satisfactory. Therefore, the corresponding response to Part 1 of this question is also not acceptable.
2. In the response to item 2 of RAI 850-6002, Question 03.07.01-30, the applicant states that the RASCAL computer code was used in the study and cites a report for RASCAL code (Reference 4 in the response). The referenced report is:
   "Silva, W., and Lee, K. 1987, "State-of-the-art for Assessing Earthquake Hazards in the United States; Report 24, WES RASCAL Code for Synthesizing Earthquake Ground Motions," Miscellaneous Paper S-73-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS."
   According to the above cited report, the RASCAL computer code accepts only single layered soil above the half space. For soil profiles considered in US-APWR a single layered soil model is not adequate. The applicant is requested to provide description and appropriate references to the software (or current version of RASCAL code) that

are used to calculate multilayered media site response for both the horizontal and vertical component of seismic motion.

3. In the response to item 3 of RAI 850-6002, Question 03.07.01-30, the applicant states that, “The horizontal SSI response analyses are performed assuming vertically propagating plane shear (SV or SH) wave-field excitations with the shear-strain-compatible damping values limited to no more than 15%, as required by SRP 3.7.1 Acceptance Criteria Item 2 (Reference 2). The vertical SSI response analysis is performed assuming vertically propagating plane compression wave-field excitation, the shear-strain-compatible damping values derived from the horizontal site response analyses are used but with their values limited to no more than 10%, as recommended by the correlation studies reported in Reference 1.” The above quoted sentences are not clear to the staff. Since the shear-strain-compatible damping limits are different for the horizontal component analysis (15%) than that for the vertical component analysis (10%), are there two strain compatible soil profiles, one for horizontal component analysis and the other for the vertical component analysis? The applicant is requested to clarify this statement.


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