RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

3/27/2014

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 960-6709 REVISION 3**
SRP SECTION:	**03.07.02 – Seismic System Analysis**
APPLICATION SECTION:	**3.7.2**
DATE OF RAI ISSUE:	**09/24/2012**

QUESTION NO. 03.07.02-219:

Section 4.2.3 of MHI's TR MUAP-12002 (R0), "Sliding Evaluation and Results," indicates that five sets of acceleration time histories will be used in the nonlinear sliding analyses for each of the six soil profiles, and these will be performed for the cracked and uncracked condition of the concrete members. The criteria in SRP Section 3.7.1.II.1.B Option 2 (for multiple sets of time histories) indicates that for nonlinear structural analyses, the number of time histories must be greater than four and the technical basis for the appropriate number of time histories are reviewed on a case-by-case basis. This review also includes the adequacy of the characteristics of the multiple time histories.

Therefore, the staff requests the applicant to (i) provide the technical basis for selection of 5 time histories, (ii) discuss whether the results from the use of the 5 time histories will be enveloped in the sliding evaluation, (iii) describe the approach used to develop the 5 sets of synthetic time histories, and provide the technical basis and the justification if different from the approach used in developing synthetic time histories for the design-basis seismic soil-structure interaction (SSI) analyses, (iv) confirm that the 5 time histories are based on real recorded ground motions, and (v) discuss whether the approach follows the guidance in SRP 3.7.1.II.1.B, and identify any departures from that guidance.

ANSWER:

As discussed with the Nuclear Regulatory Commission (NRC) staff during the Design Certification Document (DCD) Tier 2, Section 3.7.1, 3.7.2, and 3.7.3 Audit conducted in September 23-27, 2013, this answer revises and replaces the previous MHI answer that was transmitted by letter UAP-HF-13064. (ML13107B428)

(i) The number of time histories used in the analyses is five which is compliant with the SRP requirement that more than four be used. The bases for the selection of the 5 time histories used for sliding analyses are consistent with SRP 3.7.1.II.1.B requirements and are summarized below.

Required Attributes

- The Response Spectra from the amplitude factored seeds must reasonably match the certified seismic design response spectra (CSDRS), i.e., the seeds are simply factored to provide 5 percent damped response spectra that are a close match to the 5 percent damped CSDRS over the amplified frequency range of 2 to 20 Hz. The intent is to select seeds that require minimal manipulation to match the CSDRS.

- The seeds must have a reasonable duration. Long duration seed motions can be truncated to durations of between 20 and 25 seconds. Further segments of seed motions can be used. The strong motion duration, defined as the time required for the Arias Intensity to rise from 5 percent to 75 percent (D5-75), should be at least six seconds.

- Each set of time history components must show statistical independence by having an absolute value of correlation coefficient between components not exceeding 0.16.

- Northridge Mt. Baldy must be one of the five time histories.

Preferred Attributes

- The seeds have peek ground acceleration (PGA) greater than 0.10g, requiring a factor less than 3.0 to bring them to 0.3g PGA.

- Use recordings that were made digitally.

- Seeds from an earthquake of Magnitude 6.75 to 7.25.

- Recording site 20 to 60 km from the epicenter. Thus the signal will have the effects of both P and S waves.

- Recorded at medium soil to hard rock sites.

The final selected five time history seeds are listed in Table 1 below.

Table 1, Five Time History Seeds for Sliding Analyses

Earthquake	Station	Selected Segment Duration (seconds)
Chi-Chi	ILA067	24
Darfield	DFHS	25
Hector Mine	Amboy	23
Nahanni	Site 3	21[(1)]
Northridge	Mt. Baldy	22.08

[(1)] Record length of 19.095 sec. zero padded to 21 sec.

(ii) The sliding displacement computed to be used for design is computed statistically using the maximum values of sliding displacement from analyses, which utilized these 5 time histories as inputs. This is described in Sections 4.5.5 and 5.4 and MUAP-12002, Revision 1.

(iii) The five sets of synthetic time histories are developed to be compatible with the five percent damped CSDRS using the guidance of NUREG-0800 Standard Review Plan (SRP) 3.7.1.II.1.B Option 2 (Reference 1) for multiple sets of time histories since the five percent damping ratio is the damping of the dominant structural behavior of reinforced concrete structures. Specifically, for each component (earthquake time history in each direction), the average calculated response spectra and power spectral densities of the five sets of time histories envelop the CSDRS and the target power spectral densities (refer to the responses to RAI. 940-6532, Question 03.07.01-40 for the development of the target power spectral densities) in accordance with the requirements of SRP 3.7.1.II.1.B Option 1, Approach 1. The time histories also comply with the duration requirements, statistical independence, V/A and AD/V^2 ratio requirements in SRP 3.7.1.II.1.B. The time histories were developed using an iterative process that modifies the Fourier amplitudes of the selected seed time histories until the average of 5 percent damped response spectra envelop the 5 percent damped CSDRS and the average of the smoothed (± 20 percent) power spectral densities envelop the target power spectral densities. Each requirement is described below in detail:

a) The strong motion duration of each component, defined as the time required for the Arias' Intensity to rise from 5 percent to 75 percent, should be at least 6 seconds (Reference 1 – SRP 3.7.1.II.1.B) and consistent with duration criteria for earthquake magnitude and distance bins listed NUREG/CR-6728 (Reference 2).

b) The total duration of each component should be at least 20 seconds (Reference 1 – SRP 3.7.1.II.1.B, Option 1, Approach 2).

c) The time step of each component should be at most 0.01 seconds (Reference 1 – SRP 3.7.1.II.1.B, Option 1, Approach 2). All time histories developed have a time step of 0.005 seconds.

d) Each pair of developed time history components for each earthquake must demonstrate statistical independence with a computed absolute value of correlation coefficient not exceeding 0.16 (SRP 3.7.1.II.1.B).

e) For each component the ratios V/A and AD/V^2 (A, V and D are peak ground acceleration, ground velocity, and ground displacement, respectively) should be consistent with the values listed in Table 3-6 of NUREG/CR-6728 (Reference 2 and Reference 1 – SRP 3.7.1.II.1.B).

f) The average of the response spectra of the components of the five sets of time histories in one direction must envelop the target CSDRS at 5 percent damping (Reference 1 – SRP 3.7.1.II.1.B, Option 2).

g) The enveloping criterion is defined as not having more than five spectral values below and no more than 10 percent below the target response spectra using the frequency list from Table 3.7.1-1 (Reference 1 – SRP 3.7.1.II.1.B, Option 1, Approach 1).

h) The average of the smoothed (± 20 percent) power spectral densities of the components in each direction must envelop 80 percent of the target power spectral densities over the frequency range of interest (Reference 1 – SRP 3.7.1.II.1.B, Option 1, Approach 1).

(iv) The five recorded time history seeds shown in Table 1 in the response to item (i) are used to develop the five time histories for sliding analyses.

(v) The approach to develop the time histories for nonlinear analysis follows the guidance in SRP 3.7.1.II.1.B, as described in the response to item (iii) above. No departure from SRP 3.7.1.II.1.B was taken in the approach.

References:

(1) "Seismic Design Parameters," NUREG-0800, SRP 3.7.1, Rev. 3, NRC, March 2007.

(2) "Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-consistent Ground Motion Spectra Guidelines," NUREG/CR-6728, NRC, October 2001.

(3) Pacific Earthquake Engineering Research Center (2006). Pacific Engineering Research NGA Strong Motion Database, University of California, Berkeley, http://peer.berkeley.edu/nga/.

(4) GeoNet New Zealand seismograph network, GNS Science, geonet.org.nz.

Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the R-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.