



USNRC-MHI Public Meeting US APWR DCD Chapter 3

Seismic Analysis & Design Review for Sections 3.7 and 3.8

BY

Dr. Bhagwat Jain
Dr. John Ma
Vaughn Thomas

Office of New Reactors
Division of Engineering
Structural Engineering Branch -1

March 31, 2011

USNRC- MHI Public Meeting
US APWR DCD Chapter 3 (Sections 3.7 and 3.8)
March 31, 2011

Purpose:

To provide an overview of the current review status for Sections 3.7 and 3.8, and discuss key technical issues and path forward for resolving those technical issues. MHI will address the technical issues and provide its approach for resolving those issues.

Agenda:

- Status of Phase 2 Review
- Key Technical Issues
- Communications with MHI
- Overall Review Status Summary for Sections 3.7 and 3.8
- Path Forward

Staff's Phase 2 Review Status - DCD Section 3.7

- In 2009, Staff reviewed DCD rev. 0, 1, and 2, issued RAIs and held first public meeting on November 16, 2009. Staff identified Seismic SSI issue.
- In 2010, applicant revised its seismic SSI analysis approach and submitted 4 technical reports: MUAP-10001 R0 and R1, "Seismic Design Bases of the US-APWR Standard Plant," MUAP-10006 R0, "Soil-Structure Interaction Analyses and Results for the US-APWR Standard Plant," and MUAP-10002 R0, "Damping Ratio of SC Structure," between February and April 2010.
 - Staff's completed its review of the 4 MHI's technical reports: MUAP-10001 R0 and R1; MUAP-10006 R0; and MUAP-10002
 - Staff has issued RAIs related to the 4 TRs
 - Technical issues identified
- Staff generated a total of 104 RAIs. Applicant has responded to 103 of the staff RAIs of which 50% has been accepted.
- Resolution to some of the RAIs has been pending due to MHI's submittal of the following five reports that the staff received in February 2011 and 2 additional reports that are due by end of March 2011.
 - MUAP-10001 Rev 2, "Seismic Design Basis of the US-APWR Standard Plant"
 - MUAP-10006 Rev 1, "Soil-Structure Interaction Analyses and Results for the US-APWR Standard Plant"
 - MUAP-11001 Rev 0, "Seismic Evaluation of US-APWR A/B"
 - MUAP-11002 Rev 0, "Seismic Evaluation of US-APWR T/B"
 - MUAP-10024 Rev 0, "Structural design criteria for USAPWR Access Building"

MHI is scheduled to submit the following additional reports in March 2011:

- MUAP-11006 Rev 0, "FE Model Development and Verification"
- MUAP-11007 Rev 0, "FE Model Site-Independent SSI Analysis"
- Currently, staff is reviewing the technical reports received in February 2011 along with MHI's response to staff RAIs.
- Staff expects additional RAIs to be generated from the review of those technical reports.

Key Seismic Technical Issues (Section 3.7)

(1) Seismic Analysis Approach

- Validation of lumped mass stick model
 - RAIs 3.7.2-11, 13, 14, 15, 16, 17, 18
 - Lumped mass models of the R/B do not properly capture the structural response to dynamic loads in all directions

(2) SASSI model for SSI analysis

- RAIs 3.7.2-57 and 3.7.2-59 [And all the key issues identified below]
- Developing a 3-D dynamic finite element (FE) SASSI model for SSI analysis
- Report to be submitted by end of March 2011
- High frequency ground motion input
 - RAI 3.7.1-16, and draft RAI 3.7.1-17
 - Applicability of the US-APWR certified standard design response spectra (CSDRS) to hard rock sites in Central and Eastern United States (CEUS), relative to response spectra characteristic in the high-frequency range
 - MHI to provide response to RAI
- Effect of water table
 - RAIs 3.7.2-60, 3.7.2-21
 - Only two soil profiles considered in the study
 - Did not address R/B (Only addressed PS/B)
 - Unit weight of the dry and saturated soil is reported to be same with no justification
- Effect of concrete cracking
 - RAI 3.7.2-20
 - Stiffness reduced by 25%-50% due to anticipated cracking
 - MHI committed to confirm and validate its assumed pattern and extent of cracking, by a detailed dynamic finite element seismic model
- High frequency response
 - RAIs 3.7.2-57, 3.7.2-59, 3.7.2-37, 3.7.2-49
 - Models not capable to transmit frequencies of up to 50 Hz

(3) Soil-Structure Interaction (SSI) Analysis

- Selection of soil profile/ properties
 - RAIs. 3.7.2-54, 3.7.1-17
 - Parametric studies for selecting the lower boundaries of the SSI models is not provided

- Unpublished information is cited in the response but was not provided for staff review
- Soil profile properties used in the analysis do not reflect physical behavior observed in theory and testing
- ACS-SSASI version 2.3.0 dated June 2009 was used for the SSI analysis. Numerical robustness of SSASI for soft deposits application was improved and implemented in November 2009. MHI needs to demonstrate that the analyses performed using the June 2009 version is still valid and is insensitive to the changes in the later version.
- Cat II/Cat I structure
 - RAIs 3.7.2-30, 3.7.2-6, 3.7.2-16
 - MHI committed to provide seismic models of the T/B, A/B, and AC/B in separate technical reports
 - Staff received the reports in February 2011 and they are currently under review
- Embedment effect
 - RAI 3.7.2-53
 - Basis for selecting the two specific soil profiles chosen for the study is not provided
 - There are no correlation between the soil properties used in the study and the soil properties cited in the reference document

Staff's Phase 2 Review Status - DCD Section 3.8

- Staff has generated a total of 150 RAIs. MHI has responded to all of the staff RAIs of which 54% have been accepted.
- Staff is currently reviewing MHI's response to staff RAIs. In addition, staff is also participating in weekly Monday morning conference calls with applicant for clarification purposes.
- Resolutions to some of the RAIs in Section 3.8 are pending MHI's completion of 2 technical reports and 4 calculation reports.
 - MUAP-11005 Rev 0, "Research Achievements of SC Structure and Strength Evaluation of US-APWR SC Structure Based on 1/10 Scale Test Results," received in February 2011 and is currently under review.
 - REF-13-05-160-005, "Subgrade Modeling in Finite Element Analyses of Nuclear Island Structures," will be available for audit in July 2011.
 - PCV-13-05-113-001, "Design Report for the Basic Design of the PCCV for the US-APWR Standard Plant," will be available for audit in March 2011.
 - RBF-13-05-160-002, "Design Report for the Basic Design of the R/B Foundation for the US-APWR Standard Plant," will be available for audit in March 2011.
 - CIS-13-05-160-003, "Design Report for the Basic Design of the Containment Internal Structures for the US-APWR Standard Plant," is currently available for audit from February 2011.
 - MUAP-11011 Rev 0, "Technical Report to Address Structure-Soil-Structure Interaction (SSSI) for Standard Plant Structures," is due in June 2011.

Key Design Technical Issues (Section 3.8)

(4) Design reports of seismic Category I structures and their combined basemat: PCCV, containment internal structures, reactor building complex, power source buildings, and essential service water tunnel

- Submit structural member sizes and connection detail (including reinforcing steel bars sizes and locations) for those members and connections that have not been submitted
- Submit steel liner plate strains near PCCV penetrations subjected to combined membrane and bending stresses and compare them to ASME Code allowable
- Describe the effects of concrete cracking on structural analysis and member design
- Describe the effects of high water table on embedded exterior wall design due to water-soil- wall interaction
- Assess adequacy of 4-in gap between buildings considering lateral displacement due to seismic motions, concrete cracking, and differential settlement
- Demonstrate design adequacy of containment internal structures:
 - Applicability of the 1/10th scale cyclic test report
 - Sufficiency of design considerations:
 - ✓ Applicability of design methods
 - ✓ Adequacy of fire rating for the PCCV and the containment internal structures
- Define critical sections
 - Clarify the criteria used to determine the critical sections in the structures

(5) Design reports of seismic Category II structures and their basemat: turbine building and auxiliary building

- Submit structural member sizes and connection detail (including reinforcing steel bars sizes and locations) for those members and connections that have not been submitted
- Describe the effects of concrete cracking on structural analysis and member design
- Describe the effects of high water table on embedded exterior wall design due to water-soil- wall interaction
- Assess adequacy of 4-in gap between buildings considering lateral displacement due to seismic motions, concrete cracking, and differential settlement

(6) Soil foundation adequacy

- Provide and compare acting dynamic soil pressure vs. allowable dynamic soil bearing strength
- Provide allowable short-term (elastic) settlement and uneven settlement for structures during construction and corrective actions if actual vertical settlement or uneven settlement exceeds the allowable settlement
- Provide a program including monitoring allowable long-term vertical settlement and uneven settlement for structures and corrective actions if actual vertical settlement or uneven settlement exceeds the allowable settlement

Communications with MHI

- Staff is engaged in a weekly teleconference call (Mondays @ 8 AM-EST) with MHI to clarify technical issues
 - RAI questions
 - Applicant responses

Overall Phase 2 Review Status Summary Sections 3.7 and 3.8

- Staff has generated a total of 254 RAIs.
- MHI has responded to 253 of the staff RAIs
- Staff has accepted and closed out 52% of the RAI responses
- Staff is engaged with MHI to communicate its concern
- Staff continues to review applicant's technical reports and responses and provide feedback, as appropriate.

Path Forward

- Staff expects the applicant to make quality submittals that are technically sufficient and accurate, complete, and contain appropriate level of details. Staff also expects that the information is submitted on committed schedule. Any departure from the staff's expectation could potentially impact the public milestones.

- Applicant's submittal of additional technical reports (other than the two reports due by end of March 2011) or technical papers that require staff's review could potentially impact the public milestones.
- Staff will perform its review of the DCD, technical reports, and response to RAIs for compliance with the applicable regulations. Staff will issue only one round of RAIs.
- Staff will plan and conduct audits after reviewing response to RAIs.
- Technical issues that remain unresolved will be identified as Open Items in the staff's phase 2 SER.