

**NRC Feedback on KHNP's Draft and Final RAI Responses: RAI 129-8085; Q 3.8.1-1, RAI 129-8085; Q 3.8.1-4, and RAI 129-8085; Q 3.8.1-10, RAI 199-8223; Q 3.8.1-13, RAI 227-8274; Q 3.8.4-1, RAI 227-8274; Q 3.8.4-9, RAI 227-8274; Q 3.8.4-4; RAI 183-8197; Q 3.7.2-2**

**(June 16, 2016)**

**RAI 183-8197; Q 3.7.2-2**

The staff finds that markups to DCD Section 3.7.2.11 (3.7.2.12 as per response to RAI 8323, Question 3.8.1-16) are necessary to reflect the use of RSA and respective comparison with time history analysis results. The staff request the applicant to propose markups to DCD section 3.7.2.12 addressing the following:

The time-history analysis method based on complex frequency response method is used for the seismic analysis of seismic Category I structures.

Response Spectrum Analysis is used to compute the seismic design forces of the containment structure and internal structure in the reactor containment building using the in-structure response spectra at the top of the basemat generated from the seismic soil-structure interaction analysis.

The responses from these two methods are compared and provided in [To be determined by the applicant (e.g. Table 3.7-XX and/or APR1400-E-S-NR-14003-P)]

In the applicant response to Part b regarding the seismic analysis methods used for the seismic Category I structures, the applicant provided a table, Table 3.8A-40, "Summary of Models and Analysis Methods," which lists the models of the APR1400 structures along with the methods used to perform the analysis for each model. The staff reviewed the table and noted the following:

1. In Table 3.8A-40 (1 of 3 through 3 of 3), for the NI building basemat, the Aux building, the EDGB, and the FDOT analysis models, the applicant stated that the static analysis and other analysis methods are used to analyze these structures. The applicant is requested to expand on exactly what loads the static analysis method is used to analyze (e.g., dead load, live load, gravity load, etc.) using these structural models.

**KHNP Input**

**The staff's feedback is incorporated in revised Table 3.8A-40.**

2. In Table 3.8A-40 (1 of 3 and 2 of 3), for the NI building basemat, the Aux building, the EDGB, and the FDOT analysis models, the applicant stated that the static analysis and other analysis methods are used to analyzed these structures. The staff reviewed the

referenced DCD sections given in the last column of the table, as well as Sections 3.8, 3.7.2, and 3.8A of the DCD and could not identify descriptions for the different analysis methods used to analyze the structural models. The applicant is requested to provide a clear description of each of the analysis methods identified in the table in the appropriate sections of the DCD (Sections 3.8, 3.8A, and/or 3.7.2, as appropriate). Also, identify in the last column of DCD Table 3.8-40 where this information is located in the DCD.

- For example, in Table 3.8A-40, (2 of 3), for the EDGB, the static analysis, equivalent static analysis, and nonlinear analysis methods are identified. From this information it is not clear which loads are evaluated using each of these three different analysis methods. The staff reviewed DCD Section 3.8.4.4 (referenced in the last column of the table) as well as Section 3.8A.3.4.2 (which is referenced in DCD Section 3.8.4.4), 3.7.2, and 3.8A and could not find a description of the analysis methods used to analyze the EDGB structural model(s).

#### KHNP Input

The last column of the table 3.8A-40 is revised to incorporate the staff's feedback.

3. In Table 3.8A-40 (2 of 3), there are a number of row entries that are identified in the last column as "Not described in DCD." For each of these row entries, if the structure is seismic Category I then the model, analysis purpose and approach, and computer program, should identified in the DCD. In this case the last column should reference this section of the DCD. For non-seismic Category I structures, the last column could identify the row as "Not applicable" since the structure is not seismic Category I.

#### KHNP Input

Table 3.8A-40 has been revised to identify DCD sections, which the computer programs listed in Table 3.8A-40 are described in, as shown in the attachment of RAI Response.

4. In Table 3.8A-40 (1 of 3), for the "Reactor containment building internal structure model (uncracked stiffness model), under the column labelled Analysis Method, why is the entry SSE damping also included? In Table 3.8A-40 (2 of 3), for the EDGB and the DFOT building, why are these analyses only performed for shear walls? How are the other structural members like slabs, basemat, columns, etc. analyzed?

#### KHNP Input

In the question of the RAI, staff request to include damping of the analysis model in the Table. In the Table 3.8A-40 which has the information about the models used in DCD Tier 2 Section 3.8, the analysis models for the response spectrum analysis have

damping values. The SSE damping in the entry of Table 3.8A-40 moves to the inside of the bracket to make the use of damping value clear. For the EDGB and the DFOT building, structural analyses are performed for shear walls and basemat design. Table 3.8A-40 is revised to make the analyses performed for the EDGB and DFOT building clear. The structural analysis for the slabs of EDGB and DFOT was not performed since the slabs are not classified as a critical section. There is no column in the EDGB and the DFOT building.

5. Note that the KHNP response to RAI 249-8323 Question 03.08.01-15 also provides some information on the computer programs, analysis methods, models, and analysis scope. The response and markups for Table 3.8A-40 and Question 03.08.01-15 should be consistent.

#### KHNP Input

Table 3.8A-40 for Question 3.7.2-2 and Table 3.8-11 for Question 03.08.01-15 have been revised to be consistent with each other as shown in the attachment of RAI Response and attachment of NCR Feedback, respectively. Table 3.8-11 for Question 03.08.01-15 has been provided to confirm the consistency between the two tables.

## APR1400 DCD Tier 2

Table 3.8-11 (1 of 3)

### Computer Programs for Seismic Category I Structures

Program	Analysis Method	Analysis Model	Analysis Scope	Validation & Verification
ANSYS	• Modal analysis	• Reactor containment building (shell & dome, internal structure)	• Eigenvalue analysis	- ANSYS was procured with a Quality Assurance Service Agreement and meets the applicable requirements of the NQA-1, Subpart 2.7, quality assurance requirements of computer software.
		• Spent fuel pool & aux. feed water storage tank	• Eigenvalue analysis	
	• Response spectrum analysis	• Reactor containment building (shell & dome, internal structure)	• Structural analysis of seismic load for RCB	
	• Static analysis	• Reactor containment building (shell & dome, internal structure)	• Structural analysis of RCB for structure design (e.g., dead and live loads, etc.)	
		• Auxiliary building (including spent fuel pool, aux. feed water storage tank)	• Structural analysis of AB for structure design (e.g., dead and live loads, etc.) • Local analysis of spent fuel pool and aux. feed water storage tank (e.g., hydrostatic and hydrodynamic loads, etc.)	
		• Emergency diesel generator building	• Structural analysis of EDGB for structure design (e.g., dead and live loads, etc.)	
		• Diesel fuel oil storage tank building	• Structural analysis of DFOT for structure design (e.g., dead and live loads, etc.)	
	• Heat transfer analysis	• Reactor containment building (shell & dome)	• Temperature analysis	
		• Spent fuel pool	• Temperature analysis	
	• Nonlinear analysis	• NI common basemat	• Structural analysis of basemat for structure design considering nonlinear soil spring (compressive only spring, reaction of superstructures)	
		• Emergency diesel generator building basemat	• Structural analysis of EDGB for structure design considering nonlinear soil spring (compressive only spring, reaction of superstructures)	

## APR1400 DCD Tier 2

Table 3.8-11 (2 of 3)

Program	Analysis Method	Analysis Model	Analysis Scope	Validation & Verification
ANSYS (Cont.)	• Nonlinear analysis	• Diesel fuel oil storage tank building basemat	• Structural analysis of DFOT for structure design considering nonlinear soil spring (compressive only spring, reaction of superstructures)	
	• Equivalent static analysis	• Auxiliary building (including spent fuel pool, aux. feed water storage tank)	• Structural analysis of seismic load for AB	
		• Emergency diesel generator building	• Structural analysis of seismic load for EDGB	
		• Diesel fuel oil storage tank building	• Structural analysis of seismic load for DFOT	
• Direct integration time history analysis	• IRWST hydro-dynamic analysis	• Generation of floor response spectrum (FRS) due to POSRV sparger discharge load for mechanical and piping design		
ABAQUS	• Nonlinear analysis	• Reactor containment building	<ul style="list-style-type: none"> <li>• Ultimate pressure capacity evaluation corresponding to RG 1.216, Position 1 using nonlinear material model</li> <li>• Combustible gas control inside containment evaluation corresponding to RG 1.216, Position 2 using nonlinear material model</li> </ul>	- ABAQUS is validated in accordance with the registration procedure for computer software of KEPCO E&C.
DARTEM	• Static analysis	• Reactor containment building (shell & dome, internal structure, RCB basemat)	• Structural analysis and design of reinforced concrete section subjected to mechanical and thermal loads	- DARTEM is validated in accordance with the registration procedure for computer software of KEPCO E&C.
		• Auxiliary building (spent fuel pool)	• Structural analysis and design of reinforced concrete section subjected to mechanical and thermal loads	
LBAP	• Static analysis	• Reactor containment building (liner plate anchorage system)	• Structural analysis of liner plate anchorage system when liner plate buckled	- LBAP is validated in accordance with the registration procedure for computer software of KEPCO E&C.

**APR1400 DCD Tier 2**

Table 3.8-11 (3 of 3)

Program	Analysis Method	Analysis Model	Analysis Scope	Validation & Verification
GTstrudl	• Static analysis	• Auxiliary building (concrete slab analysis model)	• Structural analysis to obtain design forces for concrete slab design (e.g, dead and live loads, etc.)	- GTstrudl was procured with a Quality Assurance Service Agreement and meets the applicable requirements of the NQA-1, Subpart 2.7, quality assurance requirements of computer software.