ArevaEPRDCPEm Resource

From: Pederson Ronda M (AREVA NP INC) [Ronda.Pederson@areva.com]
Sent: Friday, August 14, 2009 5:05 PM
To: Tesfaye, Getachew
Cc: BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); VAN NOY Mark (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 248, Ch. 3
Attachments: RAI 248 Response US EPR DC.pdf

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 248 Response US EPR DC.pdf" provides technically correct and complete responses to 2 of the 25 questions.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 248 Question 03.07.02-55.

The following table indicates the respective pages in the response document, "RAI 248 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

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A complete answer is not provided for 23 of the 25 questions. The schedule for a technically correct and complete response to these questions is provided below.

Question #	Response Date

RAI 03.04.02-12	November 18, 2009
RAI 03.07.01-25	December 18, 2009
RAI 03.07.02-43	December 18, 2009
RAI 03.07.02-44	November 18, 2009
RAI 03.07.02-45	November 18, 2009
RAI 03.07.02-46	December 18, 2009
RAI 03.07.02-47	December 18, 2009
RAI 03.07.02-48	December 18, 2009
RAI 03.07.02-49	November 18, 2009
RAI 03.07.02-50	December 18, 2009
RAI 03.07.02-51	December 18, 2009
RAI 03.07.02-52	November 18, 2009
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RAI 03.07.02-54	December 18, 2009
RAI 03.07.02-56	November 18, 2009
RAI 03.07.02-57	November 18, 2009
RAI 03.07.02-58	September 29, 2009
RAI 03.08.01-33	September 29, 2009
RAI 03.08.01-34	September 29, 2009
RAI 03.08.01-35	September 29, 2009
RAI 03.08.01-36	November 18, 2009
RAI 03.08.03-19	September 29, 2009
RAI 03.08.04-7	September 29, 2009

Sincerely,

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Sent: Tuesday, July 14, 2009 7:50 PM
To: ZZ-DL-A-USEPR-DL
Cc: Candra, Hernando; Chakravorty, Manas; Xu, Jim; Patel, Jay; Miernicki, Michael; Colaccino, Joseph; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 248(2934,3030,3034,3098,3099,3100), Ch. 3

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on June 18, 2009, and discussed with your staff on July 14, 2009. No changes were made to the draft RAI questions as a result of that discussion. The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs. For any RAIs that cannot be answered within 30 days, it is expected that a date for receipt of this information will be provided to the staff within the 30 day period so that the staff can assess how this information will impact the published schedule.

Thanks,
Getachew Tesfaye
Sr. Project Manager
NRO/DNRL/NARP
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Hearing Identifier: AREVA_EPR_DC_RAIs
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Response to

Request for Additional Information No. 248 (2934,3030,3034,3098,3099,3100), Revision 0

7/14/2009

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 03.04.02 - Analysis Procedures
SRP Section: 03.07.01 - Seismic Design Parameters
SRP Section: 03.07.02 - Seismic System Analysis
SRP Section: 03.08.01 - Concrete Containment
SRP Section: 03.08.03 - Concrete and Steel Internal Structures of Steel or Concrete Containments
SRP Section: 03.08.04 - Other Seismic Category I Structures

Application Section: FSAR Ch 3

QUESTIONS for Structural Engineering Branch 2 (ESBWR/ABWR Projects) (SEB2)

Question 03.04.02-12:

Follow-up to RAI Question 03.04.02-4

The applicant has modified the FSAR to state that there are no access openings or tunnels which penetrate the exterior walls of the Nuclear Island or any other Seismic Category 1 Structure below grade elevation. This eliminates a potential path for water ingress and the staff finds this part of the response to be acceptable. However, Tier 2, Figure 1.2-50 shows a below grade access into the Tendon Gallery from the Access Building. As this interface can create a potential path for water ingress, the applicant is requested to address how water is prevented from entering into the Tendon Gallery at this location. In its description the applicant is requested to include how differential settlement between the Tendon Gallery and the Access Building has been accounted for in the design.

Response to Question 03.04.02-12:

A response to this question will be provided by November 18, 2009.

Question 03.07.01-25:

Follow-up to RAI Question 03.07.01-11

The applicant in the RAI response states that SSE damping values are consistent with the level of stress for load combinations that contain the SSE. However, the stress levels that were requested in Question 03.07.01-11 have not been provided. To support the basis for the development of In-Structure Response Spectra (ISRS) for the certified design, the applicant is requested to provide justification for the use of SSE structural damping values by providing a table of stress levels for each of the structures represented by the stick models in the dynamic analysis. This should include representative examples of stresses in both walls and floors and a comparison of these stress levels to code allowable stresses. Comparisons should be provided for in-plane stresses as well as for out-of-plane stresses. Based on the comparison of actual stress levels to code allowable stresses, a technical justification should be provided for the damping value selected for each of the structures. In addition, the technical justification for using the SSE damping should be included in the FSAR.

Response to Question 03.07.01-25:

A response to this question will be provided by December 18, 2009.

Question 03.07.02-43:

Follow-up to RAI Question 03.07.02-1

The response states that the two versions of the code are functionally the same and produce equivalent results with no significant differences. However, it does not provide a comparison of results from a building seismic analysis using the two versions (AREVA SASSI v. 4.1B and Bechtel SASSI2000, v. 3.1) as requested in Question 03.07.02-1. Because each code is being used in the analysis of Seismic Category I structures, it should be demonstrated that the codes provide similar results for the SSI analysis. The applicant is requested to run an analysis of an embedded seismic Category I structure using both versions of the code and demonstrate that the seismic response of the structure is similar for each of the programs.

Response to Question 03.07.02-43:

A response to this question will be provided by December 18, 2009.

Question 03.07.02-44:

Follow-up to RAI Question 03.07.02-3

The response does not adequately address the question which asked for the frequency transmission characteristics of the stick model as well as the FEMs used for seismic analysis. In reviewing the modal frequencies of the stick models, it is noted that for the balance of NI Common Basemat Structures, the Reactor Containment Building, and the Reactor Building Internal Structure, the highest reported frequencies as reported in FSAR Tables 3.7.2-1, 3.7.2-2, and 3.7.2-3 are 28.65 Hz, 34.98 Hz, and 35.44 Hz, respectively. As such, these models may not be appropriate for many Eastern U.S. sites where earthquakes are characterized by high frequency input. The applicant is requested to add a COL information item that requires the COL applicant to determine if the U.S. EPR seismic models are appropriate for use at the COL applicant's site because of the limitation of the seismic models to transmit high frequency input.

Response to Question 03.07.02-44:

A response to this question will be provided by November 18, 2009.

Question 03.07.02-45:

Follow-up to RAI Question 03.07.02-4

Given the thickness of the mat and stiffening effect of the attached superstructure the assumption of a rigid basemat is acceptable for determining the seismic response of the structure. As discussed in its response, the applicant is requested to provide in the FSAR a description of the methods used to evaluate the flexibility of the mat in the out-of-plane direction and how the results of this evaluation are used to determine the forces and moments that apply to the design of the mat.

Response to Question 03.07.02-45:

A response to this question will be provided by November 18, 2009.

Question 03.07.02-46:

Follow-up to RAI Question 03.07.02-05

The stick model represents a significant structural condensation of the FEM and is expected to model the global response of the structure to seismic input. The applicant in its response states that additional amplification due to flexible walls and floors is captured by the finite element model and incorporated into the tuning process. The majority of the structural resistance will be provided by in-plane shear and axial forces. It is unlikely the stick model by itself will capture the out-of-plane response of flexible floors and walls from the tuning process with the FEM. In its response to Question 03.07.02-9, the applicant states that vertical floor frequencies are determined from the independent modal analysis of the FEM. These determine SDOF oscillators for the stick models. A SDOF model is generated with the slab properties modeled in the vertical direction considering cracked and un-cracked concrete conditions. These are seismically excited and the envelope of the responses of both sticks is used to obtain zero period accelerations used in slab design. For walls, out-of-plane vibrations are evaluated in the same way as for floor slabs. However, on page 3.7-73, the FSAR states that floor and roof slabs are assumed rigid when developing the stick models for the NI Common Basemat Structures except that out-of-plane flexibilities of the following slabs and walls are explicitly accounted for by SDOF oscillators in the stick models:

- The removable walls at the steam generator (SG) towers above elevation +63 ft, 11-1/2 inches of the RBIS.
- The walls and roof slab of the SBs 2 and 3 shield structure and FB shield structure.
- The two flexible slabs at elevation +26 ft, 7 inches of SBs 2 and 3.

The applicant's response to Question 03.07.02-9 suggests that the use of SDOF oscillators is a general practice applicable to all walls and slabs not just those listed on page 3.7-73. As the FSAR and the responses to Questions 03.07.02-5 and 03.07.02-9 do not provide a clear or consistent picture of the treatment for these structural elements the applicant is requested to provide for the NI Common Basemat Structures the step-by-step process that is used to determine the amplified response of flexible slabs and walls and the generation of their respective ISRS. As part of this response the applicant is requested to address the following:

a. What are the criteria for decoupling flexible floors and walls from the main stick model?
b. Why were the walls and slabs identified on page 3.7-73 included in the stick model?
c. Identify any other flexible walls and slabs that are included in the stick model and provide the reasons they are included.
d. Identify the flexible slabs and walls that are excluded from the seismic stick model and provide the reasons for not including them.

Describe the impact of the decoupling approach on the seismic response (displacement, acceleration, ISRS) of both the NI Common Basemat Structure stick model and on the seismic response of the decoupled walls and floors.

Response to Question 03.07.02-46:

A response to this question will be provided by December 18, 2009.

Question 03.07.02-47:

Follow-up to RAI Question 03.07.02-06

The final ISRS is obtained by first developing an envelope of ISRS for the 12 soil cases for the NI common basemat structures and the 10 soil cases for the EPGB and ESWB. These are then peak broadened by 15 percent. Given that the variability in the soil has been accounted for by using this method, the staff finds the response regarding the difference in peak frequencies between the stick model and the FEM could be acceptable except as noted below that the applicant first demonstrate that the FEM itself is sufficiently detailed such that it provides accurate results for its intended use and therefore can be used as a benchmark for determining the validity of the stick model for calculating the seismic response of the NI Common Basemat Structures.

Regarding the difference between the peak acceleration of the stick model and the FEM, the applicant states that ten percent is the accuracy tolerance of loads, stresses, FS, etc. The applicant is requested to provide further basis for this statement, its relevance to the issue of the acceptability of the 10 percent difference in peaks between the two models and identify the meaning of the acronym FS. If there is a potential 10 percent tolerance in the results of the stick model and a 10 percent tolerance in the results of the FEM, collectively, there is the potential for an additional 20 percent difference in the results from that shown in the FSAR. The staff finds the response provides an insufficient basis for accepting the difference in the peaks and requests the applicant to provide additional technical justification. In addition, the applicant has not addressed the impact of the difference in results on the subsequent analysis of supported systems and equipment as requested in Part B of the original question and is requested to do so. Finally, The response provided in part (c) does not address the purpose of SRP 3.7.2-SAC-3.C.ii which is to provide assurance that the finite element model is sufficiently detailed to provide accurate results for the intended use. The applicant is requested for the NI common basemat structure, EPGB, and ESWB to demonstrate that further refinement in the finite element models of these structures would have a negligible effect on the results they produce. In summary, the applicant is requested to provide the following additional information in support of its response to Question 03.07.02-6.

a. Per SRP 3.7.2-SAC-3.C.ii, demonstrate for the NI Common Basemat Structures that the FEM is sufficiently detailed such that it can be used as a basis for determining the adequacy of the NI stick models to reasonably represent the seismic response of the NI Common Basemat Structures.

b. Although the seismic response of the EPGB and ESWB were based on FEMs and not stick models, the applicant is requested to demonstrate that the seismic models for each of these structures is sufficiently detailed that they provide accurate results from the seismic analysis of each of these structures.

c. Further clarify and provide the basis for the statement that ten percent is the accuracy tolerance of loads, stresses, FS, etc., and provide the meaning of the acronym FS. Discuss how this tolerance justifies the acceptance of a 10 percent difference between the ISRS peaks from the two seismic models.

In addition, the applicant is requested to address the impact of the difference in results on the subsequent analysis of supported systems and equipment as requested in Part B of the original RAI question 03.07.02-06.

Response to Question 03.07.02-47:

A response to this question will be provided by December 18, 2009.

Question 03.07.02-48:

Follow-up to RAI Question 03.07.02-7

The applicant cites as a basis for accepting up to a 10 percent increase in ISRS due to design changes the guidance provided for determining if a time history response spectra is acceptable when compared to its corresponding design response spectra. The guidance provided for time history generation is at a specific frequency in which the design response spectrum is compared with the response spectrum of the time history. The purpose of the guidance is to provide an acceptable basis for developing the input to the analysis. It does not state that if the input increases by up to 10 per cent at some later date that the results of the analysis are still acceptable. The criteria cited in ASCE Standard 4-98, Section 3.2.2.2.1(f) provides guidance for including a sufficient number of modes in a modal analysis, but the Standard has not been accepted by the NRC and the specific criteria does not meet the guidance of RG 1.122 regarding modal combination. Furthermore, the example cited is not the same as accepting a 10 percent increase in loads or response spectra that has occurred due to a design change or for some other reason after the initial design has been completed. A 10 percent increase may be acceptable but its acceptability must be based on a technical evaluation that documents the effect of the increase not only on the structure but also on equipment qualification, piping design, and any other subsequent analysis that used the results from the original design. The applicant is requested to provide the additional following information for staff evaluation:

a. Describe how the ISRS provided in the U.S.EPR FSAR are used in the certified design and quantify the effect of a ten percent increase in ISRS on these applications. Cite specific examples in your response.
b. Identify whether the approach of accepting up to a ten percent increase in ISRS is also applied to an increase in design loads for critical sections and if so provide a technical justification for doing so.

Provide the specific code references (ASME, AISC, ACI) that allow the use of up to a 10 percent increase in loads without performing a technical evaluation and demonstrating that the design still meets code allowables.

Response to Question 03.07.02-48:

A response to this question will be provided by December 18, 2009.

Question 03.07.02-49:

Follow-up to RAI Question 03.07.02-11

The staff is unable to determine from the applicant's response the basis for identifying locations where ISRS are generated. FSAR Section 3.7.2.3.1 does not provide this information. The applicant is again requested to provide the basis for the selection of locations for which ISRS are generated.

Response to Question 03.07.02-49:

A response to this question will be provided by November 18, 2009.

Question 03.07.02-50:

Follow-up to RAI Question 03.07.02-14

According to Figure 3.7.2-62 of the FSAR, the NAB is directly adjacent to the NI Common Basemat Structure. Although the much larger NI common base mat structure may satisfy the embedment criteria described in ASCE 4-98, it is not obvious that the criteria is appropriate for application to the NAB. In addition, no mention of structural backfill is made in FSAR Section 3.7.2.4.4 for the NAB. The applicant is requested to revise this section of the FSAR to include a description of the backfill. If backfill is present, the NAB will be strongly influenced by the response of the NI Common Basemat Structure. Even if the NAB were to meet the embedment criteria of ASCE 4-98, the effect of the NI common basemat structure on the response of the NAB by means of the backfill material makes the embedment criteria of ASCE 4-98 not applicable to this case. To justify the results of the analysis which treats the NAB as a surface founded structure, the applicant is requested to provide the results of an additional seismic analysis which addresses the embedment of the NAB and the effect of the NI Common Basemat Structure response on the NAB due to the structural backfill that exists between the two structures. Provide a comparison of this result with the existing analysis and justify why the existing analysis is acceptable. Include the results of this analysis and the results of the existing analysis in the FSAR.

Response to Question 03.07.02-50:

A response to this question will be provided by December 18, 2009.

Question 03.07.02-51:

Follow-up to RAI Question 03.07.02-16

The in-plane stiffness of structural elements along with the modeling of the soil and embedment effects will be the primary determinant of a structure's seismic response. The issue that needs to be addressed is whether the structural response as determined from the seismic model is amplified for walls and floors in the out-of-plane direction due to their flexibility relative to that of the overall structure. The staff agrees that the cutoff frequency of 40 Hz is appropriate as this represents the cutoff frequency of the time histories used for the seismic input of the certified design. The staff does not agree that it is appropriate to use un-cracked section properties of the concrete to determine whether a wall or slab meets this cutoff frequency. It is likely that under the combination of normal operating loads and seismic loads that concrete sections will crack. The use of the assumption of uncracked concrete could eliminate a significant number of walls and slabs from further evaluation, with the result that both their structural design loads and ISRS could potentially be under-predicted. The applicant makes the statement that since normal operating loads for affected slabs and walls do not exceed one-half their ultimate capacity, un-cracked properties are normally used. It isn't clear to the staff what the basis for this statement is, but the normal loads and other appropriate loads need to be combined with the seismic loads to determine whether or not a slab is in a cracked or un-cracked state. To demonstrate what the applicant has done is conservative, it is requested that the following information be provided:

a. Provide the results of analyses for typical walls and floors to demonstrate that walls and slabs with a fundamental un-cracked frequency in excess of 40 Hz remain un-cracked under the appropriate load combinations which include seismic loads. For each example provide the loads that are used in the calculation and provide the level of concrete stress.

b. Provide technical justification for the statement that since normal operating loads for affected slabs and walls do not exceed one-half their ultimate capacity, un-cracked properties are normally used. Provide examples that illustrate this conclusion.

c. Describe using examples how the fundamental frequencies of walls and floors are determined.

In its response, the applicant is requested to include in its sample locations both lower and higher elevations of the NI structures.

Response to Question 03.07.02-51:

A response to this question will be provided by December 18, 2009.

Question 03.07.02-52:

Follow-up to RAI Question 03.07.02-18

The response to RAI Question 03.07.02-6 does not describe the process used to develop ISRS for flexible walls and floors. Provide the information that was originally requested and include this response in the response to the Supplemental RAI for Question 03.07.02-5.

Response to Question 03.07.02-52:

A response to this question will be provided by November 18, 2009.

Question 03.07.02-53:

Follow-up to RAI Question 03.07.02-20

The response indicated that the Nuclear Auxiliary Building (NAB), which is a non-Seismic Category I structure, was designed using ASCE 43-05 for response level corresponding to Limit State (LS) "A" and design ground motion corresponding to the certified seismic design response spectrum. The NRC has not endorsed the provisions of ASCE 43-05 for seismic design. Furthermore, Limit State A (LS-A) corresponds to a structure near collapse under seismic loads where significant damage is expected. According to ANSI/ANS 2.26, the primary requirement for a structure designed to Limit State A is that some margin is retained such that egress is not impaired, i.e. the occupants can get out safely. Variances in input, the possible effect of aftershocks following an SSE and potential inaccuracies in accounting for non-linear structural behavior could remove remaining margin and potentially cause collapse of the structure. The NAB due to its location adjacent to Seismic Category I structures and the fact that it can potentially interfere with the safety function of a Seismic Category I structure must have a higher design margin than one that puts the structure in a condition under a seismic load that is just short of collapse. In RG 1.206, Section C.I 3.7.2.8 it states that "The applicant should describe the seismic design of non-seismic Category I structures whose continued function is not required, but whose failure could adversely affect the safety function of SSC's or result in incapacitating injury to control room occupants. The description should include the design criteria that will be applied to *ensure* protection of seismic Category I structures from structural failure of non Category I structures as a result of seismic effects." The word "ensure" means to make sure or certain, guarantee, etc. This philosophy is the basis for the acceptance criteria of SRP 3.7.2, SAC-8C in which the non-Category I structure is to be analyzed and designed to prevent its failure under SSE conditions such that the margin of safety is equivalent to that of the Category I structures. In addition, 10CFR52.47(a)(9) requires that the applicant identify and describe all differences in design feature, analysis technique, etc from the corresponding SRP acceptance criteria. Where a difference exists, the evaluation shall discuss how the proposed alternative provides an acceptable method of complying with the commission's regulations, or portions thereof, that underlie the corresponding SRP acceptance criteria. In technical report ANP-10292, AREVA has not identified any differences with SRP acceptance criteria; however, the response provided by the applicant does not demonstrate how the NAB meets acceptance criteria 8.C of SRP 3.7.2.

Regarding the RWPB, the concern for this structure is its effect on the NAB. While it is true the NAB is situated between the NI common basemat structures and the RWPB, the NAB design basis, as currently stated, is that it will be near collapse under an SSE event. It has not been designed for the additional failure of the RWPB under a seismic event. To state that because the NAB is located between the RWPB and the NI Common Basemat Structures it shields the NI Common Basemat Structures from any adverse effect of collapse of the RWPB cannot be justified by the design basis for the NAB. The applicant is requested to provide the results of an analysis which demonstrates that under an SSE load, the structure will not collapse on, or interact with, the NAB.

Part (c) of Question 03.07.02-20 requested the basis for the nonlinear models and to provide the results of the analysis using these models. That was not provided. As it appears the models are used for stability analysis, the applicant is requested to provide the results of the stability analysis for the NAB and its factor of safety against sliding and overturning (Question 03.07.02-22 already addresses the stability analysis of the Common Basemat Structures). As part of its response the applicant should provide the assumptions used in the analysis including the coefficient of friction against sliding and the basis for the properties used for the soil springs and dampers. In addition, the applicant should provide the computer codes and a description of the analysis process.

In summary, the staff is requesting that the applicant provide the following additional information:

a. As the applicant in Technical Report ANP-1092 did not identify any differences with SRP 3.7.2, the applicant is requested to demonstrate that the approach proposed in the FSAR meets the acceptance criteria of SRP 3.7.2, SAC-8C and that the NAB will have a factor of safety that is equivalent to seismic Category I structure. In its response the applicant should provide:

    i. The ratio of the elastic displacement of the structure to its inelastic displacement under the SSE load.

    ii. The ratio of the inelastic displacement to its ultimate displacement capacity.

    iii. The state of stress and strain in critical load bearing elements with a comparison against their ultimate capacity.

b. · For the RWPB, the applicant is requested to demonstrate that under an SSE event this structure will not collapse and impact the NAB. The response should include the structures displacement during a seismic event and the level of concrete strain for critical sections and its factor of safety against sliding and overturning due to an SSE.

Regarding the stability analysis of the NAB, the applicant should provide the methods of analysis, modeling assumptions, material properties and their bases (including coefficients of friction against sliding), computer codes, output results, and the calculated factors of safety against sliding and overturning for the structure.

Response to Question 03.07.02-53:

A response to this question will be provided by November 18, 2009.

Question 03.07.02-54:

Follow-up to RAI Question 03.07.02-21

In its response to Question 03.08.01-13 the applicant states that SASSI Versions 4.1B, 4.2, and SASSI2000 Version 3.1 are used to analyze soil structure interaction of the Nuclear Island Basemat, Emergency Power Generating Building and Essential Service Water Buildings. SASSI Versions 4.1B, 4.2, and SASSI2000 Version 3.1 are validated through meeting an allowable percentage to a chain of test problems. It is not clear what criteria are used to establish the allowable percentage to a chain of test problems which the validation must meet in order to be acceptable. In addition for GT STRUDL Versions 27, 28, 29 and 29.1 the applicant states that these programs are validated by confirming the computer program's solutions to a series of test problems substantially identical to those obtained from classical solutions. Input files are supplied and used in the program to correlate supplied output files. These results must meet a required allowance. It is not clear what is meant by the phrase the results must meet a required allowance. The applicant is requested to provide additional information regarding how the terms "allowable percentage" and "required allowance" are used in the validation of these programs.

Response to Question 03.07.02-54:

A response to this question will be provided by December 18, 2009.

Question 03.07.02-55:

Follow-up to RAI Question 03.07.02-26

The sections of the FSAR that are referenced in the response do not state that the forces from the static analysis have a positive or negative sign and the worst case combination is used in the design. Further, there is a discrepancy between FSAR Section 3.7.2.4.6 which states that the SRSS method is used to obtain the global maximum total member forces/moments due to three input motion components and FSAR Section 3.8.4.4.1 which states that the SRSS method or the 100-40-40 percent rule described in ASCE 4-98 are used to combine the seismic loads from three components of earthquake motion. The applicant is requested to revise the FSAR to state how the seismic loads are combined with other loads in order to achieve the worst case combination and to clarify the method of combining the effects of three components of earthquake motion such that the descriptions in FSAR Sections 3.8.4.4.1 and 3.7.2.4.6 are consistent.

Response to Question 03.07.02-55:

U.S. EPR FSAR, Tier 2, Section 3.7.2.4.6 states that the square-root-of-sum-of-squares (SRSS) rule is used to obtain global maximum total member forces/moments due to three input motion components. The sole use of these forces/moments is to generate U.S. EPR FSAR, Tier 2, Tables 3.7.2-18 through 3.7.2-25.

U.S. EPR FSAR, Tier 2, Section 3.7.2.4.6 also describes the manner in which zero period acceleration (ZPA) values are obtained from soil-structure interaction (SSI) analyses. ZPA values are calculated by using the time history method to combine the three spatial components.

U.S. EPR FSAR, Tier 2, Section 3.8 describes design procedures for the Nuclear Island (NI) common basemat structures and other seismic Category I structures. U.S. EPR FSAR, Tier 2, Section 3.8.4.4.1 states that seismic design activities are based on forces/moments that are taken from static-equivalent finite element computer models. Static-equivalent finite element models use the 100-40-40 rule to simultaneously solve for three earthquake motion component effects. To determine which load case will control design, every 100-40-40 rule permutation is analyzed for each load combination that includes seismic loading (E'). Specifically, the following 24 permutations are considered:

$+1.0*ZPA_x + 0.4*ZPA_y + 0.4*ZPA_z$
$-1.0*ZPA_x + 0.4*ZPA_y + 0.4*ZPA_z$
$+1.0*ZPA_x - 0.4*ZPA_y + 0.4*ZPA_z$
$-1.0*ZPA_x - 0.4*ZPA_y + 0.4*ZPA_z$
$+1.0*ZPA_x + 0.4*ZPA_y - 0.4*ZPA_z$
$-1.0*ZPA_x + 0.4*ZPA_y - 0.4*ZPA_z$
$+1.0*ZPA_x - 0.4*ZPA_y - 0.4*ZPA_z$
$-1.0*ZPA_x - 0.4*ZPA_y - 0.4*ZPA_z$

$+0.4*ZPA_x + 1.0*ZPA_y + 0.4*ZPA_z$
$-0.4*ZPA_x + 1.0*ZPA_y + 0.4*ZPA_z$
$+0.4*ZPA_x - 1.0*ZPA_y + 0.4*ZPA_z$
$-0.4*ZPA_x - 1.0*ZPA_y + 0.4*ZPA_z$

$+0.4*ZPA_x + 1.0*ZPA_y – 0.4*ZPA_z$
$–0.4*ZPA_x + 1.0*ZPA_y – 0.4*ZPA_z$
$+0.4*ZPA_x – 1.0*ZPA_y – 0.4*ZPA_z$
$–0.4*ZPA_x – 1.0*ZPA_y – 0.4*ZPA_z$

$+0.4*ZPA_x + 0.4*ZPA_y + 1.0*ZPA_z$
$–0.4*ZPA_x + 0.4*ZPA_y + 1.0*ZPA_z$
$+0.4*ZPA_x – 0.4*ZPA_y + 1.0*ZPA_z$
$–0.4*ZPA_x – 0.4*ZPA_y + 1.0*ZPA_z$
$+0.4*ZPA_x + 0.4*ZPA_y – 1.0*ZPA_z$
$–0.4*ZPA_x + 0.4*ZPA_y – 1.0*ZPA_z$
$+0.4*ZPA_x – 0.4*ZPA_y – 1.0*ZPA_z$
$–0.4*ZPA_x – 0.4*ZPA_y – 1.0*ZPA_z$

When load combinations include seismic loadings (E') plus one or more additional loadings with variable directionality, such as accident pipe reactions (R_a), additional permutations are created as necessary to capture all combinations that may control design. For example, accident pipe reactions contain one horizontal (R_{a_x} or R_{a_y}) and one vertical (R_{a_z}) component. A hypothetical load combination that contains only seismic and accident pipe reactions (E' + R_a) would consider the following 32 load cases:

$+1.0*ZPA_x + 0.4*ZPA_y + 0.4*ZPA_z + R_{a\_x} + R_{a\_z}$
$–1.0*ZPA_x + 0.4*ZPA_y + 0.4*ZPA_z – R_{a\_x} + R_{a\_z}$
$+1.0*ZPA_x – 0.4*ZPA_y + 0.4*ZPA_z + R_{a\_x} + R_{a\_z}$
$–1.0*ZPA_x – 0.4*ZPA_y + 0.4*ZPA_z – R_{a\_x} + R_{a\_z}$
$+1.0*ZPA_x + 0.4*ZPA_y – 0.4*ZPA_z + R_{a\_x} – R_{a\_z}$
$–1.0*ZPA_x + 0.4*ZPA_y – 0.4*ZPA_z – R_{a\_x} – R_{a\_z}$
$+1.0*ZPA_x – 0.4*ZPA_y – 0.4*ZPA_z + R_{a\_x} – R_{a\_z}$
$–1.0*ZPA_x – 0.4*ZPA_y – 0.4*ZPA_z – R_{a\_x} – R_{a\_z}$

$+0.4*ZPA_x + 1.0*ZPA_y + 0.4*ZPA_z + R_{a\_y} + R_{a\_z}$
$–0.4*ZPA_x + 1.0*ZPA_y + 0.4*ZPA_z + R_{a\_y} + R_{a\_z}$
$+0.4*ZPA_x – 1.0*ZPA_y + 0.4*ZPA_z – R_{a\_y} + R_{a\_z}$
$–0.4*ZPA_x – 1.0*ZPA_y + 0.4*ZPA_z – R_{a\_y} + R_{a\_z}$
$+0.4*ZPA_x + 1.0*ZPA_y – 0.4*ZPA_z + R_{a\_y} – R_{a\_z}$
$–0.4*ZPA_x + 1.0*ZPA_y – 0.4*ZPA_z + R_{a\_y} – R_{a\_z}$
$+0.4*ZPA_x – 1.0*ZPA_y – 0.4*ZPA_z – R_{a\_y} – R_{a\_z}$
$–0.4*ZPA_x – 1.0*ZPA_y – 0.4*ZPA_z – R_{a\_y} – R_{a\_z}$

$+0.4*ZPA_x + 0.4*ZPA_y + 1.0*ZPA_z + R_{a\_x} + R_{a\_z}$
$–0.4*ZPA_x + 0.4*ZPA_y + 1.0*ZPA_z – R_{a\_x} + R_{a\_z}$
$+0.4*ZPA_x – 0.4*ZPA_y + 1.0*ZPA_z + R_{a\_x} + R_{a\_z}$
$–0.4*ZPA_x – 0.4*ZPA_y + 1.0*ZPA_z – R_{a\_x} + R_{a\_z}$
$+0.4*ZPA_x + 0.4*ZPA_y – 1.0*ZPA_z + R_{a\_x} – R_{a\_z}$
$–0.4*ZPA_x + 0.4*ZPA_y – 1.0*ZPA_z – R_{a\_x} – R_{a\_z}$
$+0.4*ZPA_x – 0.4*ZPA_y – 1.0*ZPA_z + R_{a\_x} – R_{a\_z}$
$–0.4*ZPA_x – 0.4*ZPA_y – 1.0*ZPA_z – R_{a\_x} – R_{a\_z}$

$+0.4*ZPA_x + 0.4*ZPA_y + 1.0*ZPA_z + R_{a\_y} + R_{a\_z}$

$-0.4*ZPA_x + 0.4*ZPA_y + 1.0*ZPA_z + R_{a\_y} + R_{a\_z}$
$+0.4*ZPA_x - 0.4*ZPA_y + 1.0*ZPA_z - R_{a\_y} + R_{a\_z}$
$-0.4*ZPA_x - 0.4*ZPA_y + 1.0*ZPA_z - R_{a\_y} + R_{a\_z}$
$+0.4*ZPA_x + 0.4*ZPA_y - 1.0*ZPA_z + R_{a\_y} - R_{a\_z}$
$-0.4*ZPA_x + 0.4*ZPA_y - 1.0*ZPA_z + R_{a\_y} - R_{a\_z}$
$+0.4*ZPA_x - 0.4*ZPA_y - 1.0*ZPA_z - R_{a\_y} - R_{a\_z}$
$-0.4*ZPA_x - 0.4*ZPA_y - 1.0*ZPA_z - R_{a\_y} - R_{a\_z}$

Design is based on controlling loads. Combinations that contain out-of-phase loads do not control design and are not analyzed (e.g., $+1.0*ZPA_x + 0.4*ZPA_y + 0.4*ZPA_z - R_{a\_x} - R_{a\_z}$).

FSAR Impact:

U.S. EPR FSAR, Tier 2, Section 3.8.4.4.1 will be revised as described in the response and indicated on the enclosed markup.

Question 03.07.02-56:

Follow-up to RAI Question 03.07.02-28

In its response to Question 03.07.02-28, the applicant states that non-Category I structures are evaluated for potential interaction with Category I structures using the guidelines listed in response to Question 03.07.02-20. The response to Question 03.07.02-20 states that Appropriate Energy Absorption Factors (Fμ values) are selected from Table 5-1 of ASCE 43-05. The response reduction factors are applied to the seismically induced in-plane forces (shear and tension) and in-plane moments. According to the FSAR on page 3.7-95 the energy absorption factor selected corresponds to Limit State A (LS-A) in which the structure is designed to be near collapse under seismic loads and is expected to have significant damage. As stated in its assessment of the applicant's response to Question 03.07.02-20, variances in input could remove remaining margin and potentially cause collapse of a structure. This does not appear to meet the acceptance criteria of SRP 3.7.2, SAC-8C in which the non-Category I structure is to be analyzed and designed to prevent its failure under SSE conditions such that the margin of safety is equivalent to that of the Category I structure nor does it meet the guidelines of RG 1.206 which states in Section C.I.3.7.2.8 "The applicant should describe the seismic design of non-seismic Category I structures whose continued function is not required, but whose failure could adversely affect the safety function of SSC's or result in incapacitating injury to control room occupants. The description should include the design criteria that will be applied to ensure protection of seismic Category I structures from structural failure of non Category I structures as a result of seismic effects." For the Fire Protection Storage Tanks and Buildings the applicant states in FSAR Section 3.7.2.8 on page 3.7-98 that they will be designed for elastic behavior with no damage. The staff finds this to be acceptable for these structures. For the design of the Access Building and Turbine Building, the applicant is requested to demonstrate how the applicant's proposed approach meets the acceptance criteria of SRP 3.7.2, SAC-08.C. In its response the applicant should provide the following information:

a. Provide the specific steps that were used to determine the seismic response of both the Turbine Building and Access Building including a description of the seismic model, method of analysis, seismic input, and how the seismic loads were determined.

b. Describe how the analysis accounted for the various soil conditions considered in the U.S. EPR design and how the CSDRS were used in the analysis.

c. Provide for each structure the ratio of its elastic displacement to its inelastic displacement.

d. Provide for each structure the ratio of its inelastic displacement to its ultimate displacement capacity.

e. Provide for each structure the margins for critical load bearing elements against their ultimate capacity.

f. The main steam and feed water lines have anchor points at the Turbine Building and at the main steam valve (MSV) and main feed valve (MFV) stations. Describe how the seismic response of the main steam and feed water lines between the TB and valve stations was calculated and discuss the impact of both the inertial loads and anchor displacements on the isolation valves and the ability of these valves to operate during an SSE event. Provide a comparison of the allowable loads on these valves with the loads from the SSE.

g. For the Access Building describe how the seismic interaction assessment of the Access Building with the Safeguards Buildings 3 and 4 was conducted and provide the displacements of this structure under seismic load. Compare the total displacement between the Access Building and Safeguards Buildings 3 and 4 with the available seismic gap.

h. There appears to be an opening in the foundation of the Access Building by which personnel can enter the Tendon Gallery (see Tier 2 FSAR Figure 1.2-50). During a seismic event, these two structures will each have a different response, with the possibility that there could be a direct impact of one structure by the other at the interface. Discuss the consequences of an impact between these two structures during a seismic event. Include in the response the calculated seismic displacements in three orthogonal directions for each structure at the Tendon Gallery/Access Building interface.

i. Provide the results of the stability analysis of the Access Building and Turbine Building for both sliding and overturning.

The response also states that FSAR Table 3.7.2-29 provides parameters that establish adequacy of structural separations using safe shutdown earthquake (SSE) excitations which conforms to SRP guidance. The applicant is asked to identify which SRP guidance the response is referring to, how the parameters outlined in FSAR Table 3.7.2-29 meet the intent of the SRP guidance, and how the FSAR table provides parameters that establish the adequacy of structural separations.

Response to Question 03.07.02-56:

A response to this question will be provided by November 18, 2009.

Question 03.07.02-57:

Follow-up to RAI Question 03.07.02-29

The response does not address the question asked regarding the method of seismic analysis and the calculation of seismic displacements for conventional seismic structures. The applicant is requested to provide the method of analysis that is used for each conventional structure that has the potential to interact with a seismic Category I structure, identify its seismic input, and provide a comparison between the design seismic gap and the total calculated displacement for each seismic Category I structure and conventional seismic structure for which a potential interaction has been identified.

Response to Question 03.07.02-57:

A response to this question will be provided by November 18, 2009.

Question 03.07.02-58:

Follow-up to RAI Question 03.07.02-31

The response to RAI 108, Question 3.7.3-4 states that the FSAR will be revised to reflect a maximum time step no larger than one-tenth of the shortest period of importance e.g., the reciprocal of the cutoff frequency and in addition to use the acceptance criteria of Section 3.2.2.1(c) of ASCE 4-98. The applicant is requested to revise Section 3.7.2.1.1 of the FSAR so that it is consistent with the criteria to be used in revised FSAR Section 3.7.3.1.2.

Response to Question 03.07.02-58:

A response to this question will be provided by September 29, 2009.

Question 03.08.01-32:

Follow-up to RAI Question 3.8.1-1

The applicant's response provided additional information related to: (1) the containment accident pressure (Pa) used in the ISI schedule, and (2) the containment temperature used for design.

To complete the response to this RAI, the applicant is requested to state the magnitude of Pa as discussed in the response. If the magnitude of Pa is different than the magnitude of Pd, the applicant needs to explain the basis for selecting Pa in the ISI schedule.

Response to Question 03.08.01-32:

U.S. EPR FSAR, Tier 2, Section 6.2.6.1, explains that Pa, the maximum pressure used for in-service inspection (ISI), is conservatively set at 55 psig. This value exceeds the peak calculated containment pressure of 54.14 psig that results from the bounding main steam line break (MSLB). Pd represents containment design pressure of 62 psig, which exceeds Pa. Peak calculated containment pressure and containment design pressure are further discussed in U.S. EPR FSAR, Tier 2, Section 6.2.1.4.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 03.08.01-33:

Follow-up to RAI Question 3.8.1-14

The applicant provided additional information to address temperature effects through the RCB wall. The following additional information is needed to resolve this RAI:

1. Provide the technical basis for stating that it is not credible that both the accidental temperature in the RCB and the minimum annulus temperature will occur at the same time. The applicant states that the response to RAI 3.8.1-16 (scheduled for submission on 5/29/09), will provide information on the effect of annulus temperature variation relative to the 79F value used to date. The staff will review this information when available to determine if it will resolve this issue.
2. Provide the technical basis for the 1000-hr steel relaxation percentage used for the determination of steel relaxation in the tendons. The staff has observed that some text book steel relaxation values show increases for temperatures above 68F much greater than the 50% assumed in the RAI response (Reference: Figure 2-15 in “Modern Prestressed Concrete” by James R. Libby, 4th Edition, Van Nostrand Reinhold, 1990).
3. With regard to Figure 3.8.1-14, provided with the RAI response, clarify the location of the vertical/gamma and hoop tendons and the magnitude of the temperatures reported in the discussion related to this figure at the tendon locations.

Response to Question 03.08.01-33:

A response to this question will be provided by September 29, 2009.

Question 03.08.01-34:

Follow-up to RAI Question 3.8.1-15

The applicant provided additional information about the creep and shrinkage values used for the design of the pre-stressed concrete containment. The following additional information is needed to resolve this RAI:

1. It is stated that the pre-stress losses in EPR FSAR Table 3.8-5 were compared to losses for several operating U.S. plants and were found to be comparable. Provide or make available for audit, a summary of the comparisons that were made to support this conclusion.
2. Confirm that the Construction Specification will include the requirement to perform physical property tests in accordance with CC-2231.5 of the ASME Code.
3. With regard to Table 3.8.1-15 provided with the RAI response, explain why the creep coefficients for the cylinder and dome tendons are different for both T=0 and T=60 years. Also explain why the creep coefficient for the cylinder tendons at T=60 is the same as the creep coefficient for the dome tendons at T=0. Identify the text books referenced in Table 3.8.1.5 and relevant pages used to select the creep and shrinkage values reported in the table and make this information available for audit.

Response to Question 03.08.01-34:

A response to this question will be provided by September 29, 2009.

Question 03.08.01-35:

Follow-up to RAI Question 3.8.1-18

The applicant provided additional information about the tendon ducts used for the design of the pre-stressed concrete containment. The following additional information is needed to resolve this RAI:

1. The response states that one variation of the Freyssinet C-range post-tensioning system includes an additional polyurethane sheathing around each seven-wire strand. Explain how this coating meets the requirements of CC-2442.3 Permanent Coatings of the ASME Code. Also explain if any bonding between the tendon and surrounding grout has been assumed in the design. If so, how does the presence of the polyurethane sheathing affect these bonding assumptions?
2. Clarify how the grouting process ensures that there will be no void spaces in the corrugated steel tendon ductwork.

Response to Question 03.08.01-35:

A response to this question will be provided by September 29, 2009.

Question 03.08.01-36:

Follow-up to RAI Question 3.8.1-21

The applicant's response states that Combustible Gas Loads (CL) will be added to Table 3E.1-1 and Construction Loads (C) will be added to Table 3E.1-2. The response also states that the containment accident pressure loads (Pa) are applied to the basemat and that Table 3E.1-1 will be modified to clarify. The following additional information is needed to resolve this RAI:

1. The response states that construction loadings will be incorporated into the structural design, in combination with other loadings, as needed to produce an overall design. Clarify that these loads will be incorporated into the structural design before the completion of the design certification process. Also identify the Design Calculation Number that will document the results and when it will be available should the staff decide to perform an audit of this document.
2. The staff understands that the combustion gas loads (C), design methodology and results will be provided as part of the response to RAI 3.8.1-6. To complete the response to RAI 3.8.1-21, clarify that C loads will be incorporated into the structural design before the completion of the design certification process. Also identify the Design Calculation Number that will document the results and when it will be available should the staff decide to perform an audit of this document.
3. The response stated that Table 3E.1-1 will be modified to address the staff's question about Pa only being considered for the containment wall. The EPR FSAR markup does not appear to show the proposed modification. Please provide an appropriate markup of the FSAR.

Response to Question 03.08.01-36:

A response to this question will be provided by November 18, 2009.

Question 03.08.03-19:

Follow-up to RAI Question 3.8.3-7

The applicant's response indicates that there are two removable panels at Elevation 93 feet, 6 inches enclosing the inside face of the Steam Generator enclosures as shown in U.S. EPR FSAR Tier 2, Figure 3B-11. The response further states that the stiffness and mass of these panels was accounted for in the dynamic model with an appropriate pinned boundary condition. The following additional information is needed to resolve this RAI:

1. Explain where these panels are shown in FSAR Figure 3B-11 and provide a clearer figure illustrating the structural configuration of these panels and how they are keyed into SG cubicles.
2. Explain how the stiffness and mass of these panels were accounted for in the dynamic model. Are the panels specifically modeled in the FEM model with pinned boundary conditions?

Response to Question 03.08.03-19:

A response to this question will be provided by September 29, 2009.

Question 03.08.04-7:

Follow-up to RAI Question 3.8.4-1

The applicant's response states that the Radioactive Waste (Processing) Building (RWB) and Nuclear Auxiliary Building (NAB) are RW IIa structures designated as NS-AQ (non-safety related, augmented quality). The response further states that the RWB and the NAB are classified as neither "Seismic Category I" nor "safety related;" therefore, they (and reference to RG 1.143) are not included in U.S. EPR FSAR Tier 2, Section 3.8.4.

If the RWB and NAB structures are intended to be within the Design Certification, then the staff requires design information to perform its review. The staff notes that RG 1.143 indicates that Radwaste Structures, although not referred to as "safety related," do have some safety functions. Furthermore, SRP 3.8.4 does reference RG 1.143 as one of the regulatory guidance documents that is appropriate for such structures. Therefore, the staff requests again that the design information for these structures be provided in the FSAR.

Response to Question 03.08.04-7:

A response to this question will be provided by September 29, 2009.

U.S. EPR Final Safety Analysis Report Markups

Static Analysis and Design

Dead loads (D), live loads (L), hydrostatic loads (F), soil loads and lateral earth pressure loads (H), wind loads (W), pipe reactions (R_o), and normal thermal loads (T_o) are considered in the analysis and design of other Seismic Category I structures for the static normal load concrete and service load steel loading combinations. Concrete and steel members are designed to accommodate these static loads within the elastic range of their section strength. For concrete structures, uncracked section properties are used to proportion loadings to members. However ultimate strength design is used to reinforce concrete elements and members subjected to the normal factored loading combinations defined in Section 3.8.4.3.2.

Static fluid pressure loads are considered for design of the walls and floors of tanks and storage pools. Moving loads are considered for mobile plant equipment (e.g., cranes, hoists, truck bays in buildings, maintenance aisles).

Seismic and Other Dynamic Analyses and Design

Seismic analyses and designs of other Seismic Category I structures conform to the procedures described in Section 3.7.2. The requirements of ASCE 4-98 are used in the analysis and design of structural elements and members subjected to load combinations that include seismic loadings. Seismic accelerations are determined from structural stick models as described in Section 3.7.2. These accelerations are applied to the finite element computer models of other Seismic Category I structures as static-equivalent loads at the elevations used in the stick model. Seismic acceleration modification factors are used to adjust the equivalent static forces and moments to be consistent with the SSI model results.

Seismic SSE (E') loads are obtained by multiplying the dead load and 25 percent of the design live load by the structural accelerations obtained from the seismic analyses of each structure. A minimum of 75 percent of the roof snow load is included in the structural mass for seismic analysis of Seismic Category I structures. Seismic loads are also considered due to the mass of fluids in tanks and canals as described below for hydrodynamic loads. The full potential live load, including precipitation, is used for the local analysis of structural elements and members. Consideration is given to the amplification of seismic accelerations obtained from the structural stick model of each structure, due to local flexibility of structural elements and members. Construction loads are not included when determining seismic loads. Other temporary loads are evaluated for contributing to the seismic loads on a case-by-case basis.

03.07.02-55

~~Seismic loads from the three components of the earthquake motion are combined using the SRSS method or the 100-40-40 percent rule described in ASCE 4-98. The 100-40-40 combination is expressed mathematically as follows:~~

~~Where:~~

03.07.02-55

~~R = the reaction force or moment that is applied in the three orthogonal directions x, y, and z:~~

~~$R = (\pm 1.0R_X \pm 0.4R_Y \pm 0.4R_Z)$~~

~~$R = (\pm 0.4R_X \pm 1.0R_Y \pm 0.4R_Z)$~~

~~$R = (\pm 0.4R_X \pm 0.4R_Y \pm 1.0R_Z)$.~~

Seismic acceleration loads in three orthogonal directions are combined using a 100-40-40 percent rule. Let ZPA_x, ZPA_y, and ZPA_z be the maximum zero period accelerations in each of the three orthogonal directions at any given location. For each load combination (defined in U.S. EPR FSAR, Tier 2, Section 3.8.4.3.2) that contains seismic loads, the following (24) permutations of seismic accelerations are used to calculate seismic loads for consideration in design analyses:

- $\pm ZPA_x, \pm 0.4\ ZPA_y, \pm 0.4\ ZPA_z$
- $\pm 0.4\ ZPA_x, \pm ZPA_y, \pm 0.4\ ZPA_z$
- $\pm 0.4\ ZPA_x, \pm 0.4\ ZPA_y, \pm ZPA_z$

Design is based on the worst case scenario.

The effects of local flexibilities in floor slabs and wall panels are considered to determine if additional seismic accelerations should be applied to their design beyond those determined from the seismic stick model. Local flexibility evaluations are performed by determining the natural frequency of the floor or wall panel and comparing this to the frequency of the zero period acceleration on the applicable response spectra. Additional acceleration is applied when the natural frequency of the panel results in higher accelerations than the zero period acceleration. In cases where local flexibilities are determined to be a factor, additional out-of-plane accelerations are applied to the inertia loads on these panels for determining out-of-plane bending and shear loads.

Additional seismic loads due to accidental torsion are considered as described in Section 3.7.2. This is to account for variations in material densities, member sizes, architectural variations, equipment loads, and other variations from the values used in the analysis and design of other Seismic Category I structures. Due to these potential variations, an additional eccentricity of the mass is included at the floor elevations that are equivalent to 5 percent of the maximum building dimension.

Seismic Category I concrete structural elements and their connections are detailed for ductility in accordance with ACI 349-2001, Chapter 21.