ArevaEPRDCPEm Resource

From: Tesfaye, Getachew
Sent: Thursday, March 25, 2010 2:05 PM
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Cc: Chakravorty, Manas; Hawkins, Kimberly; Miernicki, Michael; Colaccino, Joseph; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 371 (4273,4271,4280), FSAR Ch. 3
Attachments: RAI_371_SEB2_4273_4271_4280.doc

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on February 25, 2010, and on March 24, 2010, you informed us that the RAI is clear and no further clarification is needed. As a result, no change is made to the draft RAI. 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,
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Request for Additional Information No. 371(4273, 4271, 4280), Revision 0

3/25/2010

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 03.07.01 - Seismic Design Parameters
SRP Section: 03.07.02 - Seismic System Analysis

Application Section: 03.07

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

03.07.01-28

Follow Up to RAI 215, Question 03.07.01-23:

Acceptance Criteria II.3 of SRP 3.7.2 states that to be acceptable the stiffness, mass and damping characteristics of structural systems should be adequately incorporated into the analytical models. Since it is still not clear to the staff how cable tray systems are modeled and analyzed including modeling of the localized yielding of support during higher excitation level to determine their response under a seismic load, the staff requests the following additional information described below:

A. In the first paragraph of the response it states that localized yielding of support connections were observed in a few test cases where the connections experienced large amplitude loading. This is accounted for in analysis and design by modeling connections as flexible joints with appropriately degraded rotational stiffness obtained from experimental tests of representative strut and joint configurations. It then states that if modeling with flexible connections is determined to not be conservative, other boundary conditions that produce more conservative results will be used. The applicant is requested to provide the following additional information:

1. Describe how an appropriately degraded rotational stiffness is calculated and how it will be determined that the use of flexible connections in the model is not providing conservative results.
2. Define whether the test results and the observed reduction in frequency are applicable to all three directions of motion. The applicant should provide test results or other backup information which form the basis of its response.
3. If the test results and reduction in frequency are not applicable to all three directions of response, the applicant should describe how the frequencies and loads are determined in the other direction(s).
4. Describe how the damping values were determined in the test program.

B. The third paragraph of the response makes a reference to Figure 03.07.01-23-1 which is supposed to show analytical and computer models that were developed and calibrated to evaluate the cable tray systems that were experimentally tested. The analytical and computer models were not provided in the response.

The applicant is requested to provide these models and describe how they were calibrated to evaluate the cable tray systems.

C. In the fifth paragraph of the response it states that the trays were rigidly mounted during the tests but then states that actual cable tray systems will be mounted using flexible supports. The applicant should provide examples of the flexible support systems, how they differ from those in the test program and why the test program results are still applicable especially since the test results are being used to determine the reduction in natural frequencies that occur with increasing ZPAs.

D. Regarding note 2 in revised Figure 3.7.1-16, the applicant is requested to provide the criteria used for determining that the cable tray system is significantly different from those tested and thus require a damping value of 10 percent for tray greater than 50 percent loading. The criteria should be added to the FSAR.

E. In subparagraph (b), a brief description is given regarding the determination of a reduced fundamental frequency and bracketing this frequency by +/- 20 percent. However the response is incomplete in its description of how cable tray systems are to be analyzed and design loads determined. The applicant should provide a complete description of this process containing the following information and include a description of this process in the FSAR.

1. Describe how the fundamental frequency of the cable tray system is determined.
2. Describe the seismic model of the cable tray system.
3. Describe how modal analysis is performed and if modal analysis is not used describe the methods that are used to develop cable tray design loads.
4. If modal analysis is used, describe how the modal frequencies of the cable tray system are determined and what damping values are associated with these higher frequencies.
5. Describe how three components of earthquake motion are considered and the responses combined for cable tray design.

F. In the FSAR markup on page 3.7-15 it states in note 3.D that the selected damping value, i.e. 10 percent, is to be justified when cable loadings are less than 50 percent of the maximum. However, note 3.A states that 10 percent damping is to be used with maximum cable loadings. Note 3 to Figure 3.7.1-16 states that a damping value of 7 percent should be used for cable tray systems that are unloaded or loaded less than 50 percent while note 2 to the same figure states that for cable tray systems that are significantly different than those tested use a damping value of 10 percent for tray with greater than 50 percent loading. The applicant is requested to clear up the discrepancy between the notes in the table and the notes in the Figure regarding the use of 10 percent damping.

03.07.01-29

Follow Up to RAI 215, Question 03.07.01-22:

The applicant has provided a comparison between modal damping using RG 1.61 and Rayleigh damping using assumed values for alpha and beta. The alpha and beta values used to develop the Rayleigh damping curve in Figure 3.7.1-22-1 are 0.9 and 0.00045, respectively. According to Appendix 3C.4.2.1.1 of the U.S. EPR FSAR these values are not the values used for seismic analysis as was requested by staff but are the values used for the RCS four-loop high energy line break analysis. In Appendix 3C.4.2.2 a different set of values of alpha and beta are given for the RCS seismic analysis. These values are 1.7 for alpha and .00055 for beta. As such there is inconsistency between the applicant's response to RAI 03.07.01-22 and the FSAR Appendix 3C.4.2.1.1. Use of higher values of alpha and beta can result in damping values that may not be conservative.

1. The applicant is requested to explain why two different sets of alpha and beta values were used and provide justification for the use of the higher damping values in the RCS seismic analysis and include this information in Appendix 3C of the FSAR.

2. Appendix 3C.4.2.2.1 states that a cutoff frequency of 35 cycles was used in the linear modal analysis. Now that Bell Bend response spectra curves will be included in the certified design and as these curves contain significant responses above 35 cps, the applicant is requested to provide a basis for using a cutoff frequency of 35 cps in the RCS seismic analysis. Please include the technical basis for your response and update the FSAR accordingly.

03.07.02-66

RAI from Public Meeting 12/14-15, 2009

The new FEM is composed entirely of plate and shell elements (all nodes having 6 DOF) with no brick elements (all nodes having 3 DOF), particularly for the basemat/wall elements of the model. Therefore, there is no issue associated with this model concerning connections between adjoining nodes having different DOFs. These elements, however, have effectively zero thickness leading to the following two problems:

a. When a plate element of a section of the basemat of one thickness is connected to an adjacent element of a different thickness, the centerlines of the adjacent elements are connected continuously in a single plane. However, the actual basemat is typically poured with the bottom of the basemat at one elevation. If the basemat has a varying thickness, the actual centerline does not lie in a single plane but its location changes as the thickness of the mat changes. As this has the potential to introduce non-conservative errors in the design loads for the basemat, the staff requests that the applicant evaluate the impact of the analysis simplification regarding the location of the basemat centerline on the bending evaluation of the basemat and the use of the analysis results for the design of the mat.

b. In embedding the model into the foundation, the basemat can be located with its centerline at the elevation of the nominal bottom of the basemat in which case the length of the attached walls must be increased affecting their frequency response or the centerline can be located at its actual elevation somewhat above the foundation bottom. This latter method leaves the effective lengths of attached walls approximately correct but the seismic input to the model is at an incorrect elevation. In either case the assumptions used can lead to non-conservative structural accelerations and an under prediction of seismic loads acting on the structure. The staff requests that the applicant describe the details of the placement of the embedded model into the foundation material using these plate elements and its potential effect on the accuracy of the analysis results and the impact on the building's seismic design loads.

03.07.02-67

RAI from Public Meeting 12/14-15, 2009

A new large finite element model of the Nuclear Island Common Basemat Structures was developed using the ANSYS Code. This model is too large to be directly input into the MTR/SASSI Code. Therefore, the model used for the dynamic response analysis has been reduced in size. If these models are not dynamically equivalent, non-conservative errors could be introduced in the results of the dynamic analysis. As the ANSYS model serves as the basis for the SASSI model, the applicant is requested to demonstrate and describe the process that was used to ensure that the two models (ANSYS model vs SASSI model) are dynamically equivalent and include this information in the FSAR. The staff needs this information to conclude that an adequate dynamic model was used in the analysis.

03.07.02-68

RAI from Public Meeting 12/14-15, 2009

The frequency transmission characteristics of the Nuclear Island seismic model using a finite element model to represent the common basemat structures needs to be evaluated. The criterion of DC/COL-ISG-1 (Seismic Issues of High Frequency Ground Motion) states that information should be provided to demonstrate that the SSI and structural models are of adequate refinement to assure that the high frequency components of the horizontal and vertical GMRS/FIRS of interest are properly transmitted through both segments of the computer model. For the soft soil case(s), the transmission characteristics are limited by the transmission capability of the site soils, which are softer than the concrete structural elements. The applicant is requested to describe how the problems used for SSI analyses were modeled such that the subgrade is capable of transmitting the highest frequency of interest for each of the CSDRS time histories and to present the results of any sensitivity studies that were performed to assure that the seismic models meet the frequency criterion of the ISG and include this information in the FSAR. If sensitivity studies were not performed, the applicant should provide technical justification as to why this was not done.

03.07.02-69

RAI from Public Meeting 12/14-15, 2009

During the public meeting, a preliminary calculation was reviewed in which both sliding and overturning behavior of the NI was considered. The vertical walls of the tendon gallery were treated as shear keys in which lateral wall pressures were computed from a variety of loads. If the wall is computed as moving into the soil, the total force on a given node on the wall is computed as:

$$P_T = P_P + P_H + P_S + P_D$$

If the wall is moving away from the soil, the wall pressures are computed as

$$P_T = P_A + P_H + P_S + P_D$$

Where: P_T = the total nodal force,

P_A = the total active (minimum) soil force,

P_P = the total passive (maximum) soil force,

P_H = the hydrostatic water force,

P_S = the surcharge force from any adjacent surface buildings,

P_D = the dynamic nodal force from SSI effects.

The primary problem with this approach is that the passive and active forces are apparently determined at their maximum/minimum values. In typical applications, the passive force needs a large displacement to be fully developed, while the active force needs only small displacement to reach its minimum value. The force displacement relationship of the passive and active soil forces does not appear to be incorporated into the calculation and, as a result, it may overestimate the sliding resistance and as a consequence the structure may not meet the required factor of safety for sliding. In addition, the computation of the active and passive soil forces is based on nonlinear evaluations for assumed constitutive models typically used for granular media (such as a Coulomb-Mohr model). The appropriateness of this model for a foundation material at a specific site is not discussed. Other models can lead to significantly different estimates of force for given dynamic loads.

Another issue of potential concern is the shear key. In all shear key analysis and design, the effectiveness of the shear key is limited by the sliding capacity of the soil/rock immediately below the bottom of the key. The key simply transfers the potential sliding surface from the basemat foundation level to the level of the bottom of the key. If a softer soil is encountered somewhat below the bottom of the key, the impact of the sliding capacity of this softer soil needs to be considered and included in the determination as to whether or not the structure has an adequate factor of safety against sliding. This issue is not discussed in the calculation.

As a result of the calculation review, the applicant is requested to address:

1. The appropriateness of the Coulomb-Mohr model for foundation material at specific sites and any limitations that need to be imposed on the COL applicant to assure that the use of this model for site specific conditions is justified.

2. The use of full passive pressure in the sliding calculation to achieve sliding stability, when the mobilization of this pressure may require large displacements of the structure.

3. Sliding at the base of the shear key for the soil conditions considered and any limitation that needs to be imposed on the COL applicant to ensure the effectiveness of the key for site specific soils.

03.07.02-70

Follow Up to RAI 248, Question 03.07.02-43

1. Some of the figures for Problem 2 show differences in the magnitudes of transfer function, particularly at higher frequencies. In addition, the plots extend to only 25 Hz. As the AREVA CSDRS will now include the Bell Bend Response Spectra which has a cutoff frequency higher than 50 Hz, please provide comparisons of transfer functions to 50 Hz and comment on the cause of any differences noted and the impact these differences have on the computed seismic response of EPR structures.
2. Figure 3.7.2-43-7 indicates a spike in the interpolated transfer function at about 22 Hz from the SASSI 2000 computation, but not in the AREVA version. As the spike may indicate instability in the solution which may cause errors in the computed seismic response, the applicant is requested to describe on the cause of this spike and whether or not it affects the seismic results.
3. When benchmarking various versions of SASSI and to meet 10CFR50, Appendix B quality assurance requirements for design control it is common practice to perform computations for multiple problems to ensure that the code is operating properly on a given machine, under a given FORTRAN compiler. Please provide information on the problems considered to benchmark AREVA SASSI Version 4.2PC.
4. As AREVA ported SASSI, Version 4.1B to the Windows Personal Computer (PC) platform as AREVA SASSI, Version 4.2PC, the applicant is requested to update the FSAR to capture this change.

03.07.02-71

Follow Up to RAI 248, Question 03.07.02-47:

Regarding the request in **Question 03.07.02-47** to demonstrate that the seismic models for the EPGB and ESWB are sufficiently detailed so that they provide accurate results for the seismic analysis for each of these structures, the applicant has demonstrated this at only one elevation in one direction for one of the structures (the EPGB). The information provided is insufficient to conclude that the models are sufficiently detailed to provide accurate results and meet the guidance of SRP 3.7.2, Acceptance Criteria 3.C.ii. The applicant is requested to provide additional examples for the EPGB as well as examples for the ESWB at several elevations for all three directions of seismic excitation (x,y,z).

03.07.02-72

Follow Up to RAI 248, Question 03.07.02-48:

On page 3.7-65 of the FSAR markup, the fourth bullet states that “Changes, either individually or cumulatively, that exceed these thresholds result in the evaluation of the need for reanalysis." This is referring to the third bullet which previously stated in Revision 1 of the FSAR that deviations in ISRS of less than 10 percent increase were acceptable. As the wording of the third bullet has now been superseded by the words in the FSAR markup, the applicant is requested to change or delete the current wording of the fourth bullet. In addition the applicant has not responded to that part of **Question 03.07.02-48** which asked whether the approach of accepting up to a ten percent increase in ISRS was also applicable to an increase in design loads for critical sections. Acceptance of a ten percent increase without proper evaluation could result in code allowable stresses being exceeded and would not meet 10 CFR 50, Appendix B requirements for design control. Therefore, the applicant is requested to provide a response to this question and if the response is that increases of up to 10 percent are acceptable, to provide the technical basis for the applicant's position.

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