CCNPP3eRAIPEm Resource

From: Arora, Surinder
Sent: Thursday, May 03, 2012 3:12 PM
To: Infanger, Paul; UNECC3Project@unistarnuclear.com
Cc: CCNPP3eRAIPEm Resource; Segala, John; Chakrabarti, Samir; Wilson, Anthony; Vrahoretis, Susan; Thomas, Brian; Miernicki, Michael; McLellan, Judith
Subject: Draft RAI 343 SEB2 6471
Attachments: DRAFT RAI 343 SEB2 6471.doc

Paul,

Attached is DRAFT RAI No. 343 (eRAI No. 6471). You have until May 17, 2012 to review it and decide whether you need a conference call to discuss the RAI before the final issuance. After the phone call or after May 17, 2012, the RAI will be finalized and sent to you for your response. You will then have 30 days to provide a technically complete response or an expected response date for the RAI.

Thanks

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5/3/2012

Calvert Cliffs Unit 3
UniStar
Docket No. 52-016
SRP Section: 03.07.02 - Seismic System Analysis
Application Section: FSAR 3.7.2

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

03.07.02-70

Follow-Up to Question 03.07.02-67

In RAI 316, Question 03.07.02-67, the staff had asked the applicant to provide an assessment of the SASSI subtraction method including its impact on the seismic analyses performed in support of the CCNPP3 COL application and to identify steps taken to ensure any future seismic analyses will be free of errors or anamolies identified in the DNSFB letter of April 8th, 2011.

Assessment of Part a

In Part a of its response, the applicant states that the NI, EPGB, ESWB, and NAB will be analyzed using the MTR/SASSI Modified Subtraction Method (MSM). Since the MSM can also produce analysis errors, the applicant is requested to demonstrate the validity of the MSM as applied to the site specific analysis of the NI, EPGB, ESWB, and NAB by comparing the MSM results to the results obtained using the Direct Method of analysis.

For the future seismic analysis of the Turbine Island structures the applicant has stated that it will be based on either the Subtraction or MSM with the structural responses thoroughly examined to address concerns raised by the DNFSB letter. As both the Subtraction Method and the MSM can produce analysis errors, and the phrase “thoroughly examined” lacks specificity as to what action will be taken, the applicant is requested to state that the applicability of the Subtraction Method or MSM to the Turbine Island structures will be verified by a comparison of Subtraction Method or MSM results to the results obtained using the Direct Method of analysis.

Similar to the Turbine Island structures, the Access Building is a Seismic Category II structure that has design requirements which are equivalent to those of a Seismic Category I structure. The applicant is requested to describe the method of seismic analysis to be used for this building. If the Subtraction Method or MSM is to be used, the applicant is requested to verify the applicability of either method to this structure by comparing the analysis results to the results using the Direct Method of analysis. If the Access Building is a surface founded structure and therefore not subject to the potential errors of the Subtraction Method of MSM, the applicant is requested to so state this in its response.

Assessment of Part b

In Part b of its response the applicant states that for the NI, EPGB, and ESWB the technical and software quality assurance issues raised by the DNFSB letter will be addressed as indicated in AREVA's response to U.S. EPR FSAR RAI 489, Supplement 2, Question 03.07.02-75. It further states that the methodolgy described in the referenced response provides test problems using MTR/SASSI to examine the accuracy of different impedance modeling schemes. However, for the following reasons, the staff has not accepted the response to RAI 489, Supplement 2, Question 03.07.02-75:

• The basis for the test problems and the test problem results were not included in the response. In addition the conclusion from the test problems was that the Subtraction Method is valid for limited applications and that the direct method should be used when feasible. .

• AREVA did not demonstrate that the MSM is conservative relative to the Direct Method Therefore, comparisons of the MSM to the Subtraction Method provided with the response do not necessarily support the AREVA conclusion that "the analyses performed using the Subtraction Method provided adequate seismic design demands.

Thus, with respect to the AREVA certified design, the staff considers the issues raised by the DNFSB letter to still be open. As such, the applicant is requested to provide the staff with the process by which it will address the technical and quality assurance issues raised by the DNFSB letter for the NI, ESWB, EPGB and NAB in its site specific analysis of these structures.

For the CBIS, the applicant states that the software quality assurance was addressed per the RIZZO QA program requirments and that the Subtraction Method results obtained using the RIZZO SASSI Version 1.3a were compared to a benchmark problem using the Direct Method. In order for the staff to better understand the basis for the validation and verification of the RIZZO SASSI Version 1.3a code, the applicant should provide the benchmark problem, the comparison that was performed and its applicability to the CBIS analysis for the staff's review.

The applicant states that the future seismic analysis of the Turbine Island structures will be performed using SASSI 2010.. Since the current seismic basis for the EPR certified design is SASSI 2000 and that of the CBIS is RIZZO SASSI Version 1.3a, the applicant should provide additional information on SASSI 2010 including its applicability to the seismic analysis of structures, systems and components of CCNPP3.

Assessment of Part c

In its response to Part c, the applicant provided a simplied model of the CBIS which was analyzed using both the subtraction method and the direct method of analysis. ISRS from these analyses were compared in the Y direction at 13 control points. The results of this comparison demonstrated close agreement between the methodologies for the models analyzed. However the staff believes the applicant should provide the following additional information regarding the analysies that were was performed to enable it to conclude that the Subtraction Method is applicable to the SSI analysis of the CBIS::

1. Provide the basis for selecting the indicated control points.

2. Provide additional control points at elevation -35.0.

3. Provide control points at wall locations between each floor elevation.

4. Provide comparisons of ISRS results for both the X and Z directions or provide a technical justification for not including these comparisons with the results.

5. Provide a table comparing ZPA's for the X, Y, and Z directions for the control points provided with the response and for the additional control points requested above in item's 2 and 3.

6. Since the original analysis of the CBIS assumed a N-S plane of symmetry, it effectively cut the size of the finite element model by half over that of a full model. Since there is no geometric symmetry for this structure about an E-W plane, the applicant should explain why it was necessary to further reduce the seismic model to ¼ size. If there are no size limitations of the software to perform the direct method of analysis using the ½ model, the applicant should provide results with this model comparing the Subtraction Method to the Direct Method for the staff's review.

7. If due to size limitations of the software code it is not possible to perform an analysis of the ½ model using the direct method, the applicant should demonstrate that the ¼ model of the CBIS used in the comparison is dynamically equivalent to the ½ model and provide the key parameters that support this conclusion.

8. State whether or not is was necessary to consider structure to structure interaction effects on the response of the CBIS and if so, state how these were included in the analysis.

03.07.02-71

Follow-Up to Question 03.07.02-69

1. In its response to part 2 of RAI 323, Question 03.07.02-69 regarding the value used for convective damping the applicant has included formulas for determining how equivalent spring and damping properties are determined when the modeling of the convective water mass includes the use of multiple springs. In Figure 3 of the response the applicant has provided a diagram depicting an arrangement of convective water springs that are applied when there is a partial opening between two volumes containing water. It is not clear that the assumption of springs in parallel and springs in series at the partial opening are a correct representation for the actual behavior for the convective water mass. For example, if the opening between the volumes is quite wide, it may be more appropriate to represent the convective behavior of the water as that of a single convective mass rather than two. Conversely, if the opening between the volumes is quite narrow, it may be more appropriate to represent the convective behavior of the water as that of two independent masses. The applicant is requested to provide the technical basis for the assumption that the convective behavior of two volumes of water connected through an opening can be represented by the distribution of masses and spring constants that are depicted in Figure 3. The applicant is also requested to provide the actual configuration (including dimensions) within the CBIS to which this convective model applies and to explain why in Table 1 of the applicant's response there is only a single convective mass for motion in the N-S direction even though there are openings in the walls normal to this direction at either end of the CBIS forebay.

2. In part 5 of its response to RAI 323, Question 03.07.02-69, the applicant stated that the convective and impulsive hydrodynamic loads were analyzed separately and that their respective load effects combined by the SRSS rule as recommended by ACI 350.3-06. The reason for this according to the applicant is that the convective and impulsive loads are not in phase. The applicant refers to part 2 of the response which identifies the fundamental frequency of the convective mass as approximately 0.5 Hz and the fundamental frequency of the CBIS and surrounding soil as greater than 4 Hz. However if the building response of the CBIS is dominated by a single mode for a given direction, the staff believes it is un-conservative to use the SRSS method for combining the two effects. As TID 7024 adds the convective response directly to the impulsive response, the applicant is requested to provide additional justification as to why it believes the two effects should be combined by the SRSS method and why this method is conservative.

In addition, it is not clear why the applicant states that the two hydrodynamic loads are analyzed separately when in response to part 7 of Question 03.07.02-69 the applicant indicates that the convective and impulsive water masses are both included in the SSI seismic model of the CBIS (see Figure 7 of the response). Thus the load effect of each hydrodynamic mass can be taken directly from the building's seismic analysis time history result. As the response in part 5 does not appear to agree with the approach outlined in part 7, the applicant is requested to provide the step-by-step process by which the response of the convective and impulsive hydrodynamic masses are determined and how the load effects of these masses are included in the further analysis of the CBIS.. With regard to the latter, the applicant should address in its response the following items:

- How the mass effects of the hydrodynamic loads are considered in the overturning analysis of the structure;
- How the wall pressures due to the effect of each of the hydrodynamic loads (convective and impulsive) are combined.

03.07.02-72

Follow Up to RAI 304, Question 03.07.02-60

In Question 03.07.02-60, the staff had requested additional information to determine if an adequate dynamic model had been used in the seismic analysis of the CBIS. In its response the applicant states that in developing the SASSI half model of the CBIS the thicknesses of the walls and slabs, the material properties, and the masses are taken from the STAAD model and that the elements in the plane of symmetry in the SASSI model (Figure 2) have material properties which are half of the properties of a complete plate element. As it is not clear which elements of the model (portions of the structure) were modified and what element material properties were changed, the applicant is directed to identify these elements and provide an explanation of what properties were changed and provide the basis for making the changes.

In attempting to demonstrate that the SASSI and STAAD models were dynamically equivalent, comparisons of ISRS were made on an average basis for each of two building elevations (ground floor and second floor). In the EW direction, the average results from the SASSI model indicate that the peak response is roughly 12% - 14% lower than that computed using the STAAD model. In the NS direction there was better agreement in peak responses between the SASSI result and the STAAD result with the SASSI result slightly higher than the STADD result. However there was a shift in the peak frequency of approximately 10 percent between the two models. Because the comparison that was provided was an average over a number of locations for each elevation, any differences in the response at specific points will be modulated and will not necessarily reflect the actual difference which could be greater than that shown in the applicant's response. Because ISRS are used as the basis for seismic design of suspended systems and the seismic qualification of safety-related equipment, the applicant is directed to provide a comparison of ISRS at the specific points identified in Figure 3 and Figure 4 of its response and address the impact of the potential under-prediction of peak response or frequency shifting of the peak response in the SASSI results and state why the SASSI result is technically acceptable.

03.07.02-73

Follow Up to RAI 304, Question 03.07.02-61

In **part 1** of Question 03.07.02-61, the staff had asked the applicant to provide the coefficient of friction between the CBIS structure and the sub-grade. In its response the applicant provided a coefficient of friction of 0.6 for the basemat-mudmat interface, and friction coefficient and adhesion of 0.21 and 1.2 ksf respectively for the mudmat-stratum IIC interface. The applicant further stated that the sliding evaluation considered both interface properties, and the basemat-mudmat interface with coefficient of friction 0.6 was found to be critical and used in the stability analysis of the CBIS. It was not clear from the response how the applicant determined that the basemat-mudmat interface friction of 0.6 was critical for stability evaluation. Therefore, the applicant is directed to provide a summary of the method used and the basis for the determination that the coefficient of friction of 0.6 at the basemat-mudmat interface is more critical than using a coefficient of friction 0.21 in combination with an adhesion value of 1.2 ksf at the mudmat-stratum IIC interface.

In **part 2** the staff had asked the applicant to describe the static earth pressures considered and how they were determined in the stability analysis of the CBIS. In its response the applicant replied that the PLAXIS 3D program is used in a static analysis of the CBIS to determine the static normal and shear stresses (stabilizing stresses) at the bottom of the CBIS basemat. The response goes on to state that since both the SSI analysis and the PLAXIS 3D analysis includes the effect of lateral earth pressure along the embedment depth, this effect is not used as an additional restoring force for stability evaluation. In order to be assured that the stability evaluation was performed in a conservative manner, the applicant is directed to provide the following additional information:

a) The applicant should provide a technical summary including a figure of the PLAXIS 3D model with a description of how the properties of the model were determined. A comparison of the PLAXIS 3D model to the SSI model should be provided to include a description and demonstration of the compatibility of the soil springs in the PLAXIS 3D model with that of the SSI model.
b) The applicant should describe the basis for the lateral earth pressure loads in the PLAXIS 3D model and how these were calculated.
c) For the sliding stability analysis of the CBIS, the applicant should identify the forces from the SSI analysis that were considered as driving forces and the forces from the PLAXIS 3D model that were considered as restoring forces.

d) In Letter UN#10-285, Enclosure 2, page 27 it states that the sliding shear stress is calculated as the magnitude of the vector sum of the shear stresses in the two horizontal directions. The applicant should describe how the effect of the vertical earthquake was included in the sliding stability analysis.
e) For the SSI driving forces, the applicant should confirm that for a given force, the total is a sum of the forces which occur at each node at a point in time during the time history event or if not describe how these forces are determined.
f) The normal and shear stresses occurring at the CBIS basemat are taken from the SSI analysis. The soil in the SASSI model is effectively welded to the sidewalls of the structure which may result in a net tensile load acting on the sidewalls of the structure. As a net tensile load cannot be applied by the soil, the calculated stresses in the basemat may be under-predicted. The applicant should describe if this effect was considered and if not to provide a justification for not taking it into account in the CBIS stability analysis.
g) The applicant needs to explain what is meant by the statement that since both the SSI analysis and the PLAXIS 3D analysis includes the effect of lateral earth pressure along the embedment depth, this effect is not used as an additional restoring force for stability evaluation.
h) In a public meeting held on November 1, 2011 at NRC headquarters, the applicant presented a slide addressing seismic stability analyses in which it was stated that the CBIS takes benefit of side-wall friction. In addition, Note 1 found in Table 3.8-2 indicates that friction between the side wall and backfill is utilized in determining the stability factors of safety. Since the benefit of side-wall friction was not addressed in the applicant's response, the applicant should describe its application along with a technical justification for its use in the analysis for both sliding stability and overturning stability of the CBIS.

In **part 4** the staff requested the applicant to describe how the overturning calculation and corresponding overturning factor of safety is performed for the CBIS. It appears that two separate analyses have been performed, but the details of these analyses are not clear to the staff and require further explanation as summarized in the following:

a) The applicant should identify the driving forces and restoring forces that contribute to the overturning stability calculation. The applicant should include a diagrammatic representation of the normal stresses acting at the base of the STAAD model for each of the forces considered in the stability analysis.
b) The STAAD analysis assumes that overturning takes place as a rigid body motion of the foundation. Since the PLAXIS 3D model is used to determine the soil springs for the STAAD model and the structural portion of the STAAD model should be an accurate representation of the CBIS building stiffness, it is not clear why the STAAD analysis assumes the overturning takes place as a rigid body motion. The applicant should explain what is meant by this phrase and if rigid body motion is truly used, the applicant should justify why this representation is acceptable.
c) The applicant should describe how the time-dependent accelerations from the SASSI analysis are used to determine the overturning forces in the STAAD model.
d) Using the STAAD model, the applicant in Equation 1 has identified the forces involved as dead load, water load in the forebay, seismic loads, buoyancy loads and loads from the soil and groundwater. It states that live loads and snow loads are not considered. Yet in the discussion of the point-wise evaluation for uplift performed using the PLAXIS 3D model, the response says that live loads and

snow load are included in the analysis. This is inconsistent with the overturning stability evaluation performed using the STAAD model which did not include these loads. It is also inconsistent with the description of loads provided in **part 2** of the applicant's response and with the load combinations of SRP Acceptance Criteria 3.8.5.II.3. Including these loads will add to the compressive stresses in the basemat. Therefore, the applicant is directed to provide the following:

1. Explain why different evaluation methods were used, one based on the STAAD model and one based on the PLAXIS 3D model;
2. Justify why live loads and snow loads were included in the overturning evaluation using the PLAXIS 3D model and identify what effect this has on the conclusion that there is no uplift of the CBIS mat.
3. If the live loads and snow loads were also included in the sliding stability analysis, it would result in higher horizontal restoring forces at the basemat-subgrade interface. If these loads were included in the sliding stability analysis of the CBIS, the applicant should provide technical justification for doing so and address what happens to the sliding stability factors of safety if these loads are not included.

03.07.02-74

Follow Up to RAI 304, Question 03.07.02-54

In RAI 304, **Question 03.07.02-54** the staff requested that the applicant provide additional information regarding the mesh size used in both the horizontal and vertical directions of the SSI model for the CBIS and also asked the applicant to demonstrate that the dynamic structural model was sufficiently detailed such that further refinement would have a negligible effect on the SSI analysis results. In **part 1** of its response, the applicant compared average ISRS results for a quarter of the Forebay area using the existing finite element mesh for the structure and soil with that of a refined mesh using approximately four times the total number of elements. As the applicant has provided averages of ISRS, the differences at a specific control point cannot be determined from the applicant's response. The applicant is directed to provide a comparison of the ISRS for the individual control points and justify any discrepancies that are observed. The comparison should be provided for NS, EW, and vertical directions of earthquake input. In addition, the applicant should verify that the damping value used to generate the ISRS was the FSAR value of 5 percent because higher damping values will reduce the difference in peaks between the coarse and fine mesh ISRS.

In **part 4** of its response the applicant provided information to demonstrate that further refinement of the dynamic structural model would have a negligible effect on the SSI analysis results. To support this conclusion, the applicant provided a comparison of ISRS for two fixed base models with the first model using a coarse mesh (current model) and the second model using a finer mesh. The finer mesh was obtained by dividing each of the plate elements in the MWIS and Forebay area into four elements. The ISRS provided with the response were averages of the control points selected for the comparisons. As the applicant has provided averages of ISRS, the differences at a specific control point cannot be determined from the applicant's response. The applicant is directed to provide a comparison of the ISRS at each control point and justify any differences that occur between the results for the two mesh sizes. The comparison

should be provided for NS, EW, and vertical directions of earthquake input and include additional control points on the basemat and MWIS /Forebay walls.
As part of its response to **part 4**, the applicant has included a Figure 22 which shows ISRS for E-W ground motion. A third ISRS curve has been included which is labeled “fine interior walls”. It is not clear from the applicant’s response how the model was revised to obtain this third ISRS and why it reduced the difference between the course and the fine mesh model. The applicant is directed to explain what was done to the model and why the changes improved the comparison to the course model. The applicant should also specify the damping values at which the ISRS in the **part 4** response were computed.