AP1000DCDFileNPEm Resource

From: Loza, Paul G. [lozapg@westinghouse.com]
Sent: Wednesday, May 19, 2010 3:10 PM
To: Gleaves, Bill
Cc: Buckberg, Perry; Butler, Rhonda; Lindgren, Donald A.
Subject: Acknowledgement of receipt of RAIs RAI-SRP3.7.1-SEB1-19, RAI-TR03-001 R1, -005 R2, -007 R2, and -037
Attachments: RAI-SRP3.7.1-SEB1-19.doc; RAI-TR03-001 R1.doc; RAI-TR03-005 R2.doc; RAI-TR03-007 R2.doc; RAI-TR03-037.doc

Billy,

I acknowledge receipt for Westinghouse of the following RAIs, attached:
RAI-SRP3.7.1-SEB1-19
RAI-TR03-001 R1
RAI-TR03-005 R2
RAI-TR03-007 R2
RAI-TR03-037

Thanks,

Paul

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From: Loza, Paul G.

Created By: lozapg@westinghouse.com

Recipients:
"Buckberg, Perry" <Perry.Buckberg@nrc.gov>
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Files	**Size**	**Date & Time**
MESSAGE	606	5/19/2010 3:09:36 PM
RAI-SRP3.7.1-SEB1-19.doc	42048	
RAI-TR03-001 R1.doc	53824	
RAI-TR03-005 R2.doc	50752	
RAI-TR03-007 R2.doc	54336	
RAI-TR03-037.doc	39488	

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AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP3.7.1-SEB1-19
Revision: 0

Question:

With DCD, Revision 17, the applicant changed the design of the shield building (SB) from reinforced concrete (RC) construction (7% SSE damping in DCD Table 3.7.1-1) to concrete-filled steel module (SC) construction (5% SSE damping in DCD Table 3.7.1-1). The staff performed a review of TR-03, Revision 4, to verify the critical structural damping values used in shield building dynamic analysis. The applicant did not provide information in this regard, so staff issued RAI-SRP3.7.1-SEB1-19 (a) (draft sent 4/29/2010), requesting the applicant to define the damping value(s) used for the SC module walls and to describe how this value is assigned in the ANSYS and SASSI models.

The staff also found that the applicant reduced the SB concrete modulus to 80% of nominal value, to account for concrete cracking. The 80% value is recommended by FEMA when there is little load-induced cracking. Therefore, the staff is assuming that the applicant has confirmed the seismic response level of the shield building is sufficiently low such that only minor concrete cracking occurs due to seismic loading. Damping has been recognized for many years as being a function of the structural response level. At low response levels, lower effective viscous damping has been observed; at high response levels, higher effective viscous damping has been observed The staff is concerned that SSE damping may not be appropriate to use in the shield building dynamic analyses that are relied on for generation of in-structure response spectra (ISRS). In RAI-SRP3.7.1-SEB1-19 (b), the staff requested the applicant to document in TR-03 the technical basis for the damping value assigned, in light of the observed dependence of damping on response level.

Westinghouse Response:

Design Control Document (DCD) Revision:

None

PRA Revision:

None

Technical Report (TR) Revision:

None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR03-001
Revision: 1

Question:* *(Revision 0)

The Introduction (p.1, paragraph 5) states "This document addresses seismic response spectra, soil sites, dynamic models, minor structural changes that are significant, seismic results and their impact on seismic design loads for the building structures." The staff notes that only the pressurizer compartment redesign is described in the report. Please describe in detail all the other "minor structural changes that are significant", and why these changes to the AP1000 design are necessary. Also identify the auditable documents that contain the applicable design/analysis calculations for each change.

Additional Question: (Revision 1)

Modeling and analysis of SC wall modules in SB.

TR-03, Rev 4, Section 4.0, does not describe how the SB wall modules are represented in the NI10 and NI20 seismic analysis models. Westinghouse should provide additional information on how the SC modules are characterized in the AP1000 NI analyses.

In TR-03, provide a description of how the SC modules are characterized in the AP1000 NI analyses (e.g., assumptions for "smearing" of SC element properties and for representing the SC/RC connection).

Westinghouse Response: (Revision 0)

The seismic analysis models have been revised from those reviewed during the hard rock design certification for two types of changes. Firstly, there are design changes to the AP1000 which include the shorter pressurizer, an increase in spent fuel storage within the existing pit and a revision to the bracing of the shield slab below the discharge stack. Secondly are changes to the finite element model to better reflect the structural configuration. The changes that have been incorporated into the dynamic models in addition to the redesign of the pressurizer compartment described in the report are discussed further below. All are described in the associated design calculation documenting parts of the finite element model (auxiliary and shield building, containment internal structures, dish below containment vessel, polar crane, core makeup tank).

Design changes

- A design change was made in the spent fuel pool area to permit heavier fuel racks. Masses reflecting the racks and spent fuel were updated. In addition, the water in the fuel pits was modeled as lumped masses instead of solid elements.

  Auditable document: APP-1000-S2C-032, Rev 2, Auxiliary and Shield Building Finite Element Models
  Technical Report: APP-GW-GLR-033, "Spent Fuel Racks Design and Structural Analysis."

- The shield building roof slab bracing was modified from tie rods to cross bracing to improve the seismic response.

  Auditable documents: APP-1000-S2C-032, Rev 2, Auxiliary and Shield Building Finite Element Models

Model improvements

- The dish model was modified to incorporate changes in the annulus configuration included in existing DCD figures. The annulus tunnel on the west side was deleted and replaced by concrete. In addition nodes and elements were modified in the lower shield building and upper CIS basemat to be compatible with the revised Dish model.

  Auditable documents: APP-1010-S2C-002, Rev 3, Finite Element Model of Dish
  Technical Report: APP-GW-GLR-044, "Nuclear Island Basemat and Foundation"

- The core makeup tanks were added as stick models.

  Auditable documents: APP-MV20-S2C-001, Rev 1, Core Makeup Tank Dynamic Model

- Floors in the CIS model were refined to provide better member force results for use in design.

  Auditable document: APP-1100-S2C-034, Rev 4, Finite Element Solid-Shell Model of Containment Internal Structures

- Polar Crane Model – Changes made to the model weight (3% reduction), updated SCV local stiffness, and inclusion of polar crane truck stiffness.

  Auditable documents: APP-MH01-S2C-001, Rev 2.

These changes listed above are considered minor since the nuclear island building basic configuration is not modified. They reflect structural and model changes that are made during design development.

Additional Westinghouse Response: (Revision 1)

Reference:

None

Design Control Document (DCD) Revision:

DCD revisions are not shown for each RAI. A single set of proposed revisions is given in the response to RAI-TR03-013. The revisions are based on the material in the technical report as well as in the RAI responses. The revisions include changes to Section 3.7 and the addition of a new Appendix 3G providing a summary of the seismic analyses.

PRA Revision:
None

Technical Report (TR) Revision:

The Technical Report will be revised to include the RAI responses in an appendix. Thus the proposed DCD revisions will also become a part of the technical report.

The additional structural changes that are described in this RAI will be added to the next revision of the technical report. This addition to the Technical Report will be made at the end of Section 3.0, and is provided below.

Additional structural changes are reflected in the models used for the soil and hard rock cases along with modeling improvements. These are summarized below:

- A design change was made in the spent fuel pool area to permit heavier fuel racks. Masses reflecting the racks and spent fuel were updated. In addition, the water in the fuel pits was modeled as lumped masses instead of solid elements.

- The shield building roof slab bracing was modified from tie rods to cross bracing to improve the seismic response.
- The dish model was modified to incorporate changes in the annulus configuration included in existing DCD figures. The annulus tunnel on the west side was deleted and replaced by concrete. In addition nodes and elements were modified in the lower shield building and upper CIS basemat to be compatible with the revised Dish model.
- The core makeup tanks were added as stick models.
- Floors in the CIS model were refined to provide better member force results for use in design.
- Polar Crane Model – Changes made to the model weight (3% reduction), updated SCV local stiffness, and inclusion of polar crane truck stiffness.

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR03-005
Revision: 2

Question: (Revision 0)

The second sentence of the third paragraph in Page 9 of 154 states that the (concrete) modulus of elasticity is reduced to 80% of its value to reduce stiffness to simulate cracking. Westinghouse is requested to clarify whether this reduced stiffness was used in both the dynamic seismic response analyses for generation of floor response spectra, and the equivalent static acceleration analyses for design of the structural members. If different stiffness assumptions were used, provide the technical basis for this decision. Also provide the technical basis for using 80%. Discuss this in relation to current industry guidance (e.g., ASCE 43-05, ASCE 4-98). Were any sensitivity studies conducted to determine the effect of varying the concrete stiffness on (1) the floor response spectra, and (2) the design of structural members?

Additional Question: (Revision 2)

TR-03, Rev 4, Section 4.0, states that concrete structures are modeled with linear elastic uncracked properties and that the concrete modulus is reduced to 80% of it's value to reduce stiffness to reflect observed behavior of concrete when stresses do not result in significant cracking. Staff notes the SB analyses (Levels 2 &3) have not yet been submitted. The staff reviews procedures used for analytical modeling per the SRP 3.7.2 II 3 staff guidance. To be acceptable, the stiffness, mass, and damping characteristics of the structural systems should be adequately incorporated into the analytical models. The staff's concern is that if the SB has significant cracking, there could be a reduction of the fixed-based SB frequency response leading to an unconservative estimate SSC demands.

The staff has requested that the applicant study the sensitivity of the SB seismic response to a 0.5 stiffness reduction, which is more appropriate when there is significant concrete cracking. Staff review of TR-03, Rev. 4, finds that the 0.8 factor is used for the SB analysis without justification. The staff concern is that that if the SB has significant concrete cracking there could be a shift in the fixed-based frequencies of the SB, potentially leading to an increase in the seismic demand on the SB structure and on any systems and components attached to the SB structure.

Based on the SB design changes, provide justification for the assumed 80% reduction in concrete modulus (to account for cracking) given the SB design changes and the more detailed calculations performed (e.g., Level 2 and Level 3 analyses).

Westinghouse Response: (Revision 0, 1)

The reduction to 80% is described in DCD subsection 3.7.2.3 as shown below and was reviewed during the hard rock Design Certification. This reduction reflects the observed behavior of concrete when stresses do not result in significant cracking. This reduction is applied in both the updated dynamic ANSYS analyses on hard rock sites as well as in the SASSI analyses on soil sites. The reduction is also applied in the equivalent static acceleration analyses for design of the structural members and the nuclear island basemat.

> *The finite element models of the coupled shield and auxiliary buildings, and the containment internal structures are based on the gross concrete section with the modulus based on the specified compressive strength of concrete. When the finite element or stick models of these buildings are used in time history or response spectrum dynamic analyses, the stiffness properties are reduced by a factor of 0.8 to consider the effect of cracking as recommended in Table 6-5 of FEMA 356 (Reference 5).*

Section 3.7.2.3 (page 3-81) of the FSER accepts this approach and states:

> *The use of FEMA recommendations to modify the member stiffness of the seismic model of the NI structures is consistent with current industry practice and is reasonable and acceptable.*

Reference:

5. FEMA 356, "Prestandard and Commentary for the Seismic Rehabilitation of Buildings," Federal Emergency Management Agency, November 2000.

Additional Westinghouse Response: (Revision 2)

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision: (Revision 1)

Revise second paragraph of TR-03, Section 4.0 as follows:

It is noted that Concrete structures are modeled with linear elastic uncracked properties. However, the modulus of elasticity is reduced to 80% of its value to reduce stiffness to reflect the observed behavior of concrete when stresses do not result in significant cracking as recommended in Table 6-5 of FEMA 356.

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR03-007
Revision: 2

Question:

The fourth sentence of the fourth paragraph in Page 10 of 154 states that since the water in the PCCS tank responds at a very low frequency (sloshing) and does not affect building response, the PCCS tank water mass is reduced to exclude the low frequency water sloshing mass. The staff requests Westinghouse to provide its detailed technical basis, with references and/or numerical results, for excluding the low-frequency, water sloshing mass. Westinghouse also needs to quantify the percentage of water mass in the PCCS tank that was excluded.

Additional Question: (Revision 2)

The PCCS (passive containment cooling water tank) is located on the top of the shield building and is a part of the NI10 finite element model. The applicant described the modeling approach for the PCCS tank in DCD Appendix 3G and TR-03. The staff's review has identified additional information required by the applicant. TR-03, Rev 4, Section 4.2.1, states that since the water in the PCS tank responds at a very low frequency (sloshing) and does not affect building response, the PCS tank water mass is reduced to exclude the low-frequency water sloshing mass. Comments at the 8/14/09 structural audit (Action Item #12) and the 11/18/09 meeting on Shield Building design require that Westinghouse re-examine the PCS tank sloshing model, basis of nominal 60% tank fill percentage, dimensions (i.e. height, diameter, elevation), and loading/load paths. Compare this information to existing revised seismic analyses and adjust design documents accordingly.

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Westinghouse Response: (Revision 0, 1)

Sloshing of the water in the AP1000 PCS tank was analyzed using a formula for toroidal tanks (Reference 1). The fundamental sloshing frequency given by the formula is 0.136 hertz with a modal mass equal to 65% of the water mass. Key dimensions, frequencies and effective masses of the AP600 and AP1000 tanks are shown below.

Parameter	AP600	AP1000	Units
Inside radius of tank	17.5	17.5	feet
Outside radius of tank	38.0	42.5	feet
Average water depth	20.85	22.7	feet
Sloshing frequency	0.139	0.136	Hertz
Ratio of sloshing to total mass	0.66	0.65	

The increase in tank capacity was provided by increases in both the external radius and depth. The AP600 analyses by formula gave frequencies and effective masses similar to those in the AP1000 analyses. The sloshing formula was confirmed for the AP600 by analyses of a 3D finite element model of the water in a rigid tank. The AP600 ANSYS analyses gave the same frequency but a lower modal mass of about 60% in the first two modes. In both the AP600 and AP1000 stick models of the Auxiliary and Shield Building (ASB) 60% of the water mass was considered to be sloshing. This was included in the stick model at the elevation of the tank with two masses each with 2 horizontal degrees of freedom. The sloshing mode at 0.136 hertz appears in the first four modes of the ASB stick model given in DCD Table 3.7.2-1. The total sloshing mass is 2.6% of the mass of the ASB.

The seismic analyses of the stick model show a maximum absolute acceleration of the sloshing masses of 0.13g. This occurs at a much lower frequency of 0.136 hertz than the fundamental frequency of the ASB which is between 2 and 3 hertz. The maximum acceleration of the sloshing mass of 0.13g is much lower than the 1.1 g of the structure at the base of the tank. Therefore the low frequency sloshing mode is not significant to the response of the nuclear island away from the shield building roof. The horizontal mass participating in the sloshing mode was therefore excluded from the 3D shell dynamic model of the shield building. Sloshing is considered in the hydrodynamic loads in the design calculations for the walls of the tank.

The effect of the low frequency sloshing mode was confirmed to be negligible by performing an analysis of the nuclear island stick model without the low frequency mass. The results were compared against the results with the lower frequency masses provided in revision 15 of the DCD. Comparisons were made to the maximum absolute accelerations, member forces and floor response spectra. There were no significant changes in any of the responses.

Reference:

1. J.S. Meserole, A. Fortini, "Slosh Dynamics in a Toroidal Tank," Journal Spacecraft Vol. 24, Number 6, November-December 1987.

Design Control Document (DCD) Revision: (Revision 0, 1)

~~DCD revisions are not shown for each RAI. A single set of proposed revisions is given in the response to RAI-TR03-013. The revisions are based on the material in the technical report as well as in the RAI responses. The revisions include changes to Section 3.7 and the addition of a new Appendix 3G providing a summary of the seismic analyses.~~ None

PRA Revision:

None

Technical Report (TR) Revision: (Revision 0, 1)

The Technical Report will be revised to include the RAI responses in an appendix. ~~Thus the proposed DCD revisions will also become a part of the technical report.~~

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR03-037
Revision: 0

Question:

10 CFR Part 50, Appendix A, GDC 2 requires, in part, that SSCs important to safety be designed to withstand the effects of natural phenomena such as earthquakes without loss of capability to perform their intended safety functions. Applicable guidance for implementation of and achieving compliance with the requirements set forth in GDC 2 is provided in Regulatory Guides 1.60 and 1.61. Regulatory Guide 1.60 provides a procedure that is acceptable to the staff for defining ground response spectra for input into the seismic design/analysis of nuclear power plants.

In TR-03, Revision 4, Section 4.4.1.2, the applicant added a new soil case for the deep soil site, and indicated that the deep soil site profile uses a unique input time history that is only used to develop in-structure design response spectra. The staff is unclear about how applicant would include this case as part of the seismic design basis. In TR-03, the deep soil site is not fully characterized nor is it clear regarding how the SSI analysis was performed using the CSDRS as the ground motion input. Therefore, the staff requests the applicant to provide a detailed description of the deep soil site condition, and provide the SSI results and justification for its application to the AP1000 design response spectra (CSDRS).

Westinghouse Response:

References:

Design Control Document (DCD) Revision:

None.

PRA Revision:

None.

Technical Report (TR) Revision:

None