KHNPDCDRAIsPEm Resource

From: Ciocco, Jeff
Sent: Tuesday, October 20, 2015 2:06 PM
To: KHNPDCDRAIsPEm Resource
Subject: FW: APR1400 Design Certification Application RAI 255-8285 (03.08.05 - Foundations)
Attachments: APR1400 DC RAI 255 SEB1 8285.pdf

From: Ciocco, Jeff
Sent: Monday, October 19, 2015 9:20 AM
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Subject: APR1400 Design Certification Application RAI 255-8285 (03.08.05 - Foundations)

KHNP,

The attachment contains the subject request for additional information (RAI). This RAI was sent to you in draft form. Your licensing review schedule assumes technically correct and complete responses within 30 days of receipt of RAIs. However, KHNP requests, and we grant, the following response times for this RAI. We may adjust the schedule accordingly.

03.08.05-2: 30 days
03.08.05-3: 60 days
03.08.05-4: 60 days
03.08.05-5: 60 days
03.08.05-6: 30 days
03.08.05-7: 60 days
03.08.05-8: 60 days
03.08.05-9: 60 days
03.08.05-10: 30 days
03.08.05-11: 60 days
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03.08.05-13: 60 days
03.08.05-14: 60 days
03.08.05-15: 60 days
03.08.05-16: 60 days
03.08.05-17: 60 days
03.08.05-18: 60 days

Please submit your RAI response to the NRC Document Control Desk.

Thank you,

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Protecting People and the Environment

REQUEST FOR ADDITIONAL INFORMATION 255-8285

Issue Date: 10/19/2015
Application Title: APR1400 Design Certification Review – 52-046
Operating Company: Korea Hydro & Nuclear Power Co. Ltd.
Docket No. 52-046
Review Section: 03.08.05 - Foundations
Application Section: srp 3.8.5

QUESTIONS

03.08.05-2

10 CFR 50.55a, and 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. Standard Review Plan (SRP) 3.8.5, Section I.1.A, “Containment Structure Foundation,” last sentence, states “In prestressed concrete containments with a tendon inspection gallery, the review includes the arrangement of the gallery and means of either isolating it from the remainder of the base slab or relying on it for some function, such as resisting shears.,” and in SRP 3.8.5 Section II.4.I. “Detail explanation of the load path from all superstructures to the mat foundation to the subgrade. Discussion of any unique design features that occur in the load path (e.g., any safety-related function that the tendon gallery may have as part of the foundation in a prestressed containment or the connection of any internal structures to a steel containment and its supporting foundation).”

In DCD Tier 2, Section 3.8.5.I.1, “Description of Foundations,” the applicant did not described the tendon gallery provding access to the vertical tendons below the wall-basemat junction. Furthermore, in Section 3.8.5.II.4, “Design Analysis Procedures,” the applicant did not provided any safety-related function that the tendon gallery may have as part of the foundation in a prestressed containment and its supporting foundation. Therefore, the applicant is requested to address the following, and include this information in DCD Section 3.8.5:

Applicant is requested to provide a description of the tendon gallery, any safety-related function that the tendon gallery may have as part of the foundation in a prestressed containment and its supporting foundation as well as applicable loads and load combinations and analysis in the AP1400 foundation design.

03.08.05-3

10 CFR 50.55a, and 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. Standard Review Plan (SRP) 3.8.5, Section I.1.A, “Containment Structure Foundation,” states “If shear keys are used for such purposes, the review covers the general arrangement of the keys.”

In DCD Tier 2, Section 3.8.5.I.1, “Description of Foundations,” the applicant did not provide any description of shear keys below the foundations of seismic Category I structures. Technical report APR1400-E-S-NR-14006-P, Rev. 1, only mentions shear keys beneath the NI common basemat and the DFOT, without any descriptions and information on the analysis and design. Therefore, the applicant is requested to address the following, and include this information in DCD Section 3.8.5:

Applicant is requested to provide a description of all shear keys that are included in the foundation of APR1400 seismic Category I structures. In addition, a description should be included regarding the modeling, analysis, and design of these shear keys.

03.08.05-4

10 CFR 50.55a, and 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. Standard Review Plan (SRP) 3.8.5, Section I.1.A, “Containment Structure Foundation,” states “If waterproofing membranes are used, the review addresses their effect on the shear resistance of the foundation.”

In DCD Tier 2, Section 3.8.5.I.1, “Description of Foundations,” the applicant did not provide any description whether waterproofing membranes are used. Therefore, the applicant is requested to address the following, and include this information in DCD Section 3.8.5:

Applicant is requested to descript, whether waterproofing membranes are used in APR1400 design, and if used, provide effects on the shear resistance of the NI common basemat.

03.08.05-5

10 CFR 50.55a, and 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. Standard Review Plan (SRP) 3.8.5, Section II.2, “Applicable Codes, Standards, and Specifications,” refers to SRP Section 3.8.1, Subsection II.2 and SRP Section 3.8.4, Subsection II.2 for the applicable codes, standards, and guidance that apply to seismic Category I foundations.

In Figure 3-11, “Justification Boundary for Design of NI Common Basemat,” in Topical Report APR1400-E-S-NR-14006-P, Rev. 1, “Stability Check for NI Common Basemat,” the applicant provided the applicable codes of ASME Section III, Division 2 and ACI 349 for the containment basemat, and NI basemat, respectively. It is not clear to the staff whether the applicant performed a study comparing the differences, if any, in loads and load combinations between those industry design codes. Therefore, the applicant is requested to address the following, and include this information in DCD Section 3.8.5:

REQUEST FOR ADDITIONAL INFORMATION 255-8285

Applicant is requested to describe whether the applicant performed a study comparing the differences in loads and load combinations between design codes of ASME Section III, Division 2 and ACI 349. Furthermore, provide a discussion about the differences of loads and load combinations of those codes that may adversely affect the analytical results of APR1400 containment and NI common basemats.

03.08.05-6

10 CFR 50.55a and 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. Standard Review Plan (SRP) 3.8.5, Section I.8., “Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC),” states “... the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.”

In AP1400, DCD Tier 2, Figure 1.2-1, “Typical APR1400 Site Arrangement Plan,” the applicant provided a diagonally lined pattern legend that identified the structures within the scope of design certification for the APR1400, which included the diesel fuel oil tank building, essential service water/component cooling water heat exchanger building. In Table 3.2-1, “Classification of Structures, Systems, and Components,” the applicant classified the emergency diesel generator building including the diesel fuel oil tank building, and essential service water building and essential service water/component cooling water heat exchanger building.

In APR1400 DCD Tier 1, Section 2.2.2, “Emergency Diesel Generator (EDG) Building,” the applicant described that EDG building block is located adjacent to the east side of the Nuclear Island (NI) with a seismic isolation gap, and comprises two buildings, one that houses additional two generators and the other for the diesel fuel oil tank (DFOT) building. Furthermore, in DCD, Tier 1, Table 2.2.2-1, “Definition of Wall Thicknesses for EDG Building,” the applicant tabulated the key dimensions of DFOT building. However, the applicant did not provided any ITAAC item for the DFOT building.

In APR1400, DCD Tier 1, Table 2.2.1-3, “Seismic Classification of the Building,” the applicant identified the essential service water supplier and component cooling water heat exchanger building as seismic Category I structures. In DCD Tier 2, Section 3.8.6, “Combine License Information,” the applicant provided COL item COL 3.8(1) for the COL applicant to provide the design of site-specific seismic Category I structures, which included the essential service water building and component cooling water heat exchanger building. However, the applicant did not described for the COL applicant the requirements of ITAAC items associated with the essential service water building and component cooling water heat exchanger building.

Therefore, the applicant is requested to address the following:

1. Applicant is requested to provide the ITAAC items, associated figures, etc. for DFOT building in Section 2.2.2 of APR1400 DCD, Tier 1 .
2. Applicant is requested to describe for the COL applicant the requirements of ITAAC items associated with the essential service water building and component cooling water heat exchanger building in COL 3.8(1) in Section 3.8.6 of APR1400 DCD, Tier 2.

03.08.05-7

10 CFR 50.55a and 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. Standard Review Plan (SRP) Section 3.8.5.I.3, "Load and Load Combinations," states, "These should also include the loads that are induced by the construction sequence and by the differential settlements of the soil under and to the sides of the structures." Furthermore, SRP Section 3.8.5.I.4, "Design and Analysis Procedures,", states, "Where a single mat foundation is used for multiple plant structures, attention is given to bending, shear, and similar factors in the basemat that are attributable to uneven settlement, construction sequence, and mat flexibility."

In DCD Tier 2, Section 3.8.6.4, "Design and Analysis Procedures," the applicant stated "The maximum differential settlement of foundation is 12.7 mm per 15.24 m (0.5 in per 50 ft) within NI common basemat. The maximum differential settlement between buildings is 12.7 mm (0.5 in) based on enveloping properties of subsurface materials. In addition, the common basemat is analyzed for construction sequences to minimize any potential differential settlement during construction." The applicant further described the differential settlement of foundations in Appendix 3.8A, "Structural Design Summary," and in technical report APR1400-E-S-NR-14006-P, Rev. 1, "Stability Check for NI Common Basemat." However, it is not clear to the staff how the construction sequence and differential settlement of foundations were considered in the load and load combinations. Therefore, the applicant is requested to describe how the construction sequence and differential settlement of foundations were considered in the load and load combinations. Also, DCD Section 3.8.5 should be updated accordingly.

03.08.05-8

10 CFR 50.55a and 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. Standard Review Plan (SRP) Section 3.8.5.II4.H.A states, "Appropriateness of the method for determination of the bending moments and shear forces in the mat foundation for seismic loads."

DCD Tier 2, Section 3.8.5.4, "Design and Analysis Procedures," states, "The analysis of the foundation mat is performed by a three-dimensional finite element structure model, and the forces and moments determined in the analysis are input to the structural design." However, it is not clear to the staff how seismic and other loads are determined and applied to the various structures within the scope of the APR1400 design. Therefore, the applicant is requested to address the following, and include this information accordingly in DCD Sections 3.8.1, 3.8.3, 3.8.4 and 3.8.5:

(a) Provide identification and description of the method of analysis used, whether response spectra analysis method, equivalent static method of analysis, or the use of forces from the SSI/SSSI analyses and application of these to the separate FEM design model.

(b) Provide description how the response spectra, equivalent static accelerations, or forces from the SSI/SSSI were developed and then applied to the FEM design model.

(c) For the response spectra analysis (RSA), provide the RSA curves used in the analysis of the structure.

(d) Explain how the static accelerations from the seismic SSI/SSSI analyses were transferred to the separate FEM design model since the two models have different nodes and elements.

03.08.05-9

10 CFR 50.55a and 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. Standard Review Plan (SRP) Section 3.8.5.II.4.H.E, states, "Detailed explanation of how settlement is evaluated, including potential effects of static or dynamic differential settlement, dependence on time (i.e., short term vs. long term), effect of the soil type (i.e., granular vs. cohesive), and effect of the foundation type and size (e.g., basemats, spread footings). Evaluation of the effects of settlement on construction procedures. Evaluation of the allowable settlement (total and differential) that can be accommodated in the foundation/structures." Also, SRP Section 3.8.5.II.4.H.J, states, "Explanation of how loads attributable

to construction are evaluated in the design. Some examples of items to be discussed include the excavation sequence and loads from the construction sequence of the mat foundation and walls, as well as the potential for loss of subgrade contact (e.g., because of loss of cement from a mud mat) that may lead to a differential pressure distribution on the mat." SRP Section 3.8.5.II.4.H.K, states "An essential aspect of the design and analysis procedures for seismic Category I foundations is the stiffness modeling of the soil material under and to the sides of the structures. Soil stiffness can be represented by means of analytical or numerical (e.g., solid finite elements, distributed springs) formulations that are appropriate for the loading conditions as well as for the soil type, foundation type and size, and time scale being considered."

In DCD Tier 2, Section 3.8.5.4.2, "Analysis of Settlement during Construction," the applicant provided limited description as to how settlement is evaluated. In the applicant's technical report (TR) APR1400-ES-NR-14006-P, Rev 1, "Stability Check for NI Common Basemat," the applicant describes the evaluation of the settlement of the NI basemat; however, Section 3.8.5.4 of the DCD does not reference the report. Furthermore, it is not clear to the staff how the criteria in SRP 3.8.5.II.4 E, J, and K are implemented.

Therefore, the applicant is requested to describe the design and analysis procedures to explain how the elements described in SRP 3.8.5.II.4 E, J and K are incorporated in APR14000 design, and include this information in DCD Section 3.8.5.

03.08.05-10

10 CFR 50.55a and 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. Standard Review Plan (SRP) Section 3.8.5.II.4.H.E, states, "Detailed explanation of how settlement is evaluated, including potential effects of static or dynamic differential settlement, dependence on time (i.e., short term vs. long term), effect of the soil type (i.e., granular vs. cohesive), and effect of the foundation type and size (e.g., basemats, spread footings). Evaluation of the effects of settlement on construction procedures. Evaluation of the allowable settlement (total and differential) that can be accommodated in the foundation/structures."

In DCD Tier 2, Appendix 3.8A, "Structural Design Summary," subsection 3.8A.3.4.1, "Basemat," the applicant describes the settlement analysis performed for the EDG & DFOT basemats and refers to Table 3.8A-39, "EDG & DFOT Buildings Differential Settlement According to Site Profile (static)," for the differential settlements calculated at different nodes of the EDG and DFOT buildings. However, the locations of the nodes were not provided in a similar fashion as they were for the NI basemat (as in Figures 3.8A-18 and -19). Therefore, the applicant is requested to provide the locations of nodes at the EDG & DFOT basemats for checking settlements, and include this information in DCD Appendix 3.8A.

03.08.05-11

10 CFR 50.55a and 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. Standard Review Plan (SRP) Section 3.8.5.II.4.H.A states, "Appropriateness of the method for determination of the bending moments and shear forces in the mat foundation for seismic loads." SRP Section 3.8.5.II.3, Load and Load Combinations, states, "The specified loads and load combinations used in the design of seismic Category I foundations are acceptable if found to be in accordance with those combinations described in Subsection II.3 of SRP Section 3.8.1 for the containment foundation and with those combinations listed in Subsection II.3 of SRP Section 3.8.4 for all other seismic Category I foundations." SRP Section 3.8.5.II.4.B states, "For seismic Category I concrete foundations other than the containment foundations, the procedures are in accordance with the ACI 349, with additional guidance provided by RG 1.142."

In DCD Section 3.8A.2.4.1, “Basemat,” the applicant describes the analysis and design methods for the AB basemat. Based on the staff’s review, the staff identified the following items that need to be addressed to ensure that the analysis and design methods are acceptable.

(a) For the AB and EDG buildings, equivalent static analyses were performed. SRP 3.7.2 II.1.B indicates that when using an equivalent static analysis method, justification should be provided to show that the system can be realistically represented by a simple model and the method produces conservative results in terms of responses. Therefore, applicant is requested to provide justification that the use of the equivalent static method of analysis is appropriate for the AB and the EDG buildings.

(b) In DCD Tier 2, in subsection 3.8.5.4.1, “Analysis for Loads during Operations,” and Appendix 3.8A subsection 3.8A.2.4.1, “Basemat,” the applicant stated that the reinforced concrete foundations for the seismic Category I structures are analyzed and designed for the reactions due to static, seismic and all “*other significant loads*” at the base of the superstructures supported by the foundation. It is not clear to the staff why the applicant only identifies “*other significant loads*” and not all other loads. Therefore, applicant is requested to describe why it only identifies “*other significant loads*” and not all other loads.

(c) In DCD Tier 2, Appendix 3.8A,”Structural Design Summary,” subsection 3.8A.2.4.1, “Basemat,” the applicant stated that, “Since the rigid connection between walls and basemat is not simulated in the analysis model of the NI common basemat structure, the basemat of the AB is not subject to any moment that might occur. Therefore, the additional structural analysis was executed to obtain the magnitude of the moment transferred from walls and columns, which were subjected to lateral loads.” The applicant’s approach is not clear to the staff. Therefore, applicant is requested to explain, in sufficient detail, the analysis model, boundary conditions, soil springs, how loads were applied, what accelerations are applied, and why it appears that only additional moments from the walls and columns are applied, and not all forces from the superstructure above the basemat. If only forces from the superstructure were included, then the applicant is requested to explain how the forces from the basemat inertial response were considered in the seismic analysis. The applicant is also requested to explain whether the seismic analysis of the AB basemat was performed separately, or was considered in the same NI concrete basemat model and analysis described in DCD Section 3.8A.1.4.2 used to obtain the member forces.

(d) In DCD Tier 2, Appendix 3.8A,”Structural Design Summary,” subsection 3.8A.2.4.1, “Basemat,” the applicant stated that, “The required reinforcements for axial force and out-of-plane flexural force are determined for combined bending and axial load according to the ACI design handbook (ACI 340R).” The ACI handbook follows the strength designing method of ACI 318, rather than ACI 349. Therefore, applicant is requested to explain why the ACI design handbook (ACI 340R) was considered acceptable.

03.08.05-12

10 CFR 50.55a and Appendix A to 10 CFR Part 50, General Design Criteria 1, 2, 4, 16 and 50, provide the regulatory requirements for the design of the containment internal structures. Standard Review Plan (SRP) 3.8.5, Section II specifies analysis and design procedures applicable to the foundation of seismic Category I structures.

Technical Report (TR) APR1400-E-S-NR-14006-P, Rev 1, “Stability Check for NI Common Basemat,” Section 3.2.5, “Applied Loads,” states, “The reactions from seismic analyses of the RCB shell and dome,

RCB internal structure, and AB are applied as the seismic loads in the basemat model. The response spectrum analysis is used for the RCB shell and dome and RCB internal structure and the equivalent static analysis is used for the AB for seismic analyses of superstructures." The applicant did not provide a justification for using the two different methods. Per 10 CFR 50.55a; Appendix A to 10 CFR Part 50, General Design Criteria 1, 2, 4, 16 and 50; and SRP 3.8.5, the applicant is requested to address the following:

a. Provide a justification for using the two different methods, the spectrum analysis and the equivalent static methods, for the seismic design of RCB shell and dome; and the RCB internal structures.
b. Explain whether this was done only for stability check or for all aspects of design: developing member forces for design, stability evaluation (sliding and overturning), uplift evaluation analysis, basemat soil bearing pressure calculation, settlement analysis, and lateral soil pressure on foundation walls. Wherever, this approach was used should be justified.
c. Section 3.2.5 also states that "In the response spectrum analysis, the maximum values of individual modes occur simultaneously; hence, the combined effect is obtained by using algebraic (considering signs) summation of the individual modal responses." This is not consistent with combining modes as described in NRC RG. 1.92. Therefore, the basis for this approach needs to be justified.

03.08.05-13

10 CFR 50.55a and Appendix A to 10 CFR Part 50, General Design Criteria 1, 2, 4, 16 and 50, provide the regulatory requirements for the design of the containment internal structures. Standard Review Plan (SRP) 3.8.5, Section II specifies analysis and design procedures applicable to the foundation of seismic Category I structures.

Technical Report (TR) APR1400-E-S-NR-14006-P, Rev 1, "Stability Check for NI Common Basemat," Section 3.2.6, "Load Combinations," states that, "The division of the basemat by code jurisdiction at the thickness transition is a logical choice, and the boundary of the code jurisdiction is conservatively designed using the greater forces from the analysis results of ASME and ACI codes." It is not clear to the staff as to how the applicant consider the loads and load combinations for the basemat of the containment and the Auxiliary building (AB), and how the applicant design the transition region. For example, it is not clear whether the division of the basemat code jurisdiction at the thickness transition is in accordance with the ASME Code Interpretation: 111-2-83-01, which covers this design configuration and how do they define the transition region. Per 10 CFR 50.55a; Appendix A to 10 CFR Part 50, General Design Criteria 1, 2, 4, 16 and 50; and SRP 3.8.5, the applicant is requested to describe in more detail how the loads and load combinations for the basemat of the containment and the AB, were considered in the analysis and how the transition region is design.

03.08.05-14

10 CFR 50.55a and Appendix A to 10 CFR Part 50, General Design Criteria 1, 2, 4, 16 and 50, provide the regulatory requirements for the design of the containment internal structures. Standard Review Plan (SRP) 3.8.5, Section II specifies analysis and design procedures applicable to the foundation of seismic Category I structures.

Technical Report (TR) APR1400-E-S-NR-14006-P, Rev 1, "Stability Check for NI Common Basemat," Section 4.2.2, "Sliding Check," states that, "The resistance forces against sliding of the common basemat are checked for the driving shear forces generated for the seismic load. The basemat friction force is considered to resist the sliding of

the common basemat." The applicant further stated that coefficient of friction for sliding check is 0.7. The applicant's approach for evaluating the sliding analyses of the Category I structures is not clear to the staff. SRP 3.8.5 II.4.G and B provides the criteria for determining the sliding forces and overturning moment of the Category I structures subject to seismic loads. Per 10 CFR 50.55a; Appendix A to 10 CFR Part 50, General Design Criteria 1, 2, 4, 16 and 50; and SRP 3.8.5, the applicant is requested to provide a detail description of the method used to determine the sliding check of the Category I structures; and to justify that the coefficient of friction of 0.7 represents the minimum coefficient of friction considering the various sliding interfaces including concrete to soil, waterproofing to soil, and concrete basemat to concrete mudmat.

03.08.05-15

10 CFR 50.55a and Appendix A to 10 CFR Part 50, General Design Criteria 1, 2, 4, 16 and 50, provide the regulatory requirements for the design of the containment internal structures. Standard Review Plan (SRP) 3.8.5, Section II specifies analysis and design procedures applicable to the foundation of seismic Category I structures.

Technical Report (TR) APR1400-E-S-NR-14006-P, Rev 1, "Stability Check for NI Common Basemat," Section 4.2.2, "Sliding Check," states that, "The resistance forces against sliding of the common basemat are checked for the driving shear forces generated for the seismic load. The basemat friction force is considered to resist the sliding of the common basemat." The applicant further stated that coefficient of friction for sliding check is 0.7. The applicant's approach for evaluating the sliding analyses of the Category I structures is not clear to the staff. SRP 3.8.5 II.4.G and B provides the criteria for determining the sliding forces and overturning moment of the Category I structures subject to seismic loads. Per 10 CFR 50.55a; Appendix A to 10 CFR Part 50, General Design Criteria 1, 2, 4, 16 and 50; and SRP 3.8.5, the applicant is requested to provide a detail description of the method used to determine the sliding check of the Category I structures; and justify that the coefficient of friction of 0.7 represents the minimum coefficient of friction considering the various sliding interfaces including concrete to soil, waterproofing to soil, and concrete basemat to concrete mudmat.

03.08.05-16

10 CFR 50.55a and Appendix A to 10 CFR Part 50, General Design Criteria 1, 2, 4, 16 and 50, provide the regulatory requirements for the design of the containment internal structures. Standard Review Plan (SRP) 3.8.5, Section II specifies analysis and design procedures applicable to the foundation of seismic Category I structures.

Technical Report (TR) APR1400-E-S-NR-14006-P, Rev 1, "Stability Check for NI Common Basemat," Section 2, "Site Profiles for the APR1400 Nuclear Island Common Basemat," describes the generic site profiles for the APR 1400 NI common basemat. The staff reviewed this section and noted that additional information is needed in order to perform its safety review of the DCD application. Per 10 CFR 50.55a; Appendix A to 10 CFR Part 50, General Design Criteria 1, 2, 4, 16 and 50; and SRP 3.8.5, the applicant is requested to address the following:

a. Section 2.2, "Review of the Elastic Modulus of Generic Sites," states that "The HFE program is in effect from the start of the design through the completion of the initial plant startup testing program. At startup the HFE program results will be provided to the combined operating license (COL) holder." The applicant is requested to describe what the HFE program is and how it relates to the design and analysis during the design certification phase and COL phase.

b. Section 2.2.1, "Elastic Modulus of Soil Sites," describes the approach used to develop the static elastic modulus E_{static} and the dynamic elastic modulus $E_{dynamic}$ used in the finite element models. The following items need to be addressed:

1. The approach for E_{static} is based on the relationship between E_{static} and the standard penetration test (STP) blow count. For the type of large structures in the APR1400 design, E_{static} is not normally generated using relationships based on STP blow counts. Therefore, the applicant is requested to utilize accepted industry methods for development of E_{static}.

2. The uncertainty in the relationships presented in APR1400-E-S-NR-14006-P, Rev.1, Section 2.2.1 between SPT blow count (N) and shear wave velocity (V_s) is very high. Any COL applicant will have to use site-specific measurements to define velocity profiles, including layer velocities and uncertainties, thicknesses, etc. that will then be used to compare with the range of profiles used in the DCD design. Therefore these SPT relationships are not considered acceptable for use in defining properties utilized in the design within the DCD and the technical report. Similarly, site velocity properties defined for rock layers will have to be generated by measurements and not by the relationships described in APR1400-E-S-NR-14006-P, Rev.1, Section 2.2 and Figure 2-2. The applicant is requested to adequately address the uncertainty between the STB blow count and the shear wave velocity.

3. The approach used for $E_{dynamic}$ is the elastic modulus. From the information provided, it is not clear how this formulation was used to capture the effects of soil confinement when representing the soil by compression only truss elements in the model. The applicant is requested to provide a detail description regarding its dynamic elastic approach.

4. APR1400-E-S-NR-14006-P, Rev.1, Section 2.2.1 indicated that the relationship between Elastic and Edynamic at the soil site is 0.1153. This ratio appears to be extremely low and is probably due to the questions raised in Item (a) and (b) above. The applicant is requested to update the approach to calculating Estatic/Edynamic and confirm the adequacy of the resulting ratio based on other sources of information and industry practice.

c. In Section 2.3, "Material Properties and subgrade Modulus of Site Profiles for the APR1400," it is stated, "The subgrade moduli of three site profiles are obtained from an ANSYS analysis." The description of the development of the moduli should be expanded in order to understand the approach used. The applicant is requested to provide an explanation of the following: (1) whether only a vertical static 1 ksf load was applied to obtain the vertical soil moduli, (2) whether the vertical load was applied only to the basemat foundation region, (3) what is the technical basis for indicating that the horizontal subgrade moduli were determined using two-thirds of the horizontal displacement caused by what appears to be a vertically applied pressure load, and (4) if the LINK180 ANSYS element is only utilized to represent the soil in the settlement analysis and construction sequence, why is the horizontal moduli needed.

03.08.05-17

10 CFR 50.55a and Appendix A to 10 CFR Part 50, General Design Criteria 1, 2, 4, 16 and 50, provide the regulatory requirements for the design of the containment internal structures. Standard Review Plan (SRP) 3.8.5, Section II specifies analysis and design procedures applicable to the foundation of seismic Category I structures.

Technical Report (TR) APR1400-E-S-NR-14006-P, Rev 1, "Stability Check for NI Common Basemat," Section 4.1.2, "Differential Displacement," describes the approach used to develop the differential displacements within the NI and between the NI and the adjacent TGB. For seismic loading, the relative displacements were determined at only two specific time steps where the maximum average and minimum average of displacements over the entire time history were determined. Also, APR1400-E-S-NR-14006-P, Rev.1, Section 4.1.2 indicates that the differential settlement for seismic loading is calculated based on the maximum and minimum displacements of the basemat (not the differential settlements per 50 ft). This information is not clear. Per 10 CFR 50.55a; Appendix A to 10 CFR Part 50, General Design Criteria 1, 2, 4, 16 and 50; and SRP 3.8.5, the applicant is requested to explain how the differential displacements were determined. Also explain why this does not consider the differential displacements at all time steps, which might lead to a higher differential displacement.

Additionally, in TR APR1400-E-S-NR-14006-P, Rev 1, "Stability Check for NI Common Basemat," Section 4.1.2, "Differential Settlement," the applicant provided Table 4-3, "Differential Settlements Between NI Basemat and TGB Basemat (Static Loading Case),"which shows the differential settlement between between the NI basemat and the TGB basemat. The staff reviewed the table and noted that the differential settlement for S4 (for moderate site properties), which is 0.250", is much larger than the differential settlements for S1, which is 0.091", and S8, which is 0.018", (for weak and strong site properties, respectively). The applicant is requested to address this discrepancy.

03.08.05-18

10 CFR 50.55a and Appendix A to 10 CFR Part 50, General Design Criteria 1, 2, 4, 16 and 50, provide the regulatory requirements for the design of the containment internal structures. Standard Review Plan (SRP) 3.8.5, Section II specifies analysis and design procedures applicable to the foundation of seismic Category I structures.

Technical Report (TR) APR1400-E-S-NR-14006-P, Rev 1, "Stability Check for NI Common Basemat," Section 5.0, "Construction Sequence Analysis," describes the construction sequence analyses performed for the NI basemat, and indicates that Sites S1 and S8 were used for the calculations. Figure 2-1, "Shear Wave Velocity of Generic Site Categories," indicates that site S-2 is softer than Site S1 in the top 100' of the profile and will be expected to lead to larger construction settlements and structural demands. Per 10 CFR 50.55a; Appendix A to 10 CFR Part 50, General Design Criteria 1, 2, 4, 16 and 50; and SRP 3.8.5, the applicant is requested to provide the basis for using the Site S1 rather than S-2. Also, if any site considered for construction of the APR1400 design has soil conditions that lead to settlements greater than those computed for S1 and S8 in the DCD and technical report, explain how that will be addressed.

Additionally, the staff believes that most construction sequence studies are based on assuming either (1) a sand profile where settlements occur instantaneously as load is applied, or, (2) a fine-grained soil where settlements are delayed due to potential time-consolidation effects. These two bounding profiles can lead to different demands on the structural elements. Also, an evaluation of short term and long term settlements are normally evaluated for the basemat and the superstructures, and incorporated into the design. The above considerations could not be identified in the analysis and design of the basemat and superstructures. Therefore, the applicant is requested to address how settlement and construction sequences during the short term condition of the basemat and superstructure, as well as long term condition were considered in the analysis studies and in the design of the basemat and superstructures.

Also, it is not clear how a differential displacement of 0.5 in. per 50 ft. can be used by the COL applicant to confirm the design adequacy of the basemat and superstructure. Usually, displacement of basemat results in bending distortion between adjacent points, not simply differential displacements. Therefore, the applicant is requested to

explain how the COL applicant is supposed to check for settlements, and revise the technical report, applicable sections of the DCD, and COL item(s) accordingly.