RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**255-8285**
SRP Section:	**03.08.05 - Foundations**
Application Section:	**03.08.05**
Date of RAI Issue:	**10/19/2015**

Question No. 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 3.8.5.1, "Description of Foundations," the applicant did not described the tendon gallery providing access to the vertical tendons below the wall-basemat junction. Furthermore, in Section 3.8.5.4, "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 APR1400 foundation design.

Response

The nuclear island (NI) common basemat of the APR1400 includes a hollow rectangular toroid for the tendon gallery. The tendon gallery provides a space to install and inspect the inverted "U" shaped vertical tendons. It is located entirely within the NI reinforced concrete basemat, as shown in Figures 3.8-1 and 3.8-2 of the APR1400 DCD. The vertical tendons run up the cylindrical shell, over the dome in a non-radial mesh pattern, run down to the tendon gallery on the opposite side, and are anchored at each end in the tendon gallery, as shown in Figure 3.8-4 of the DCD.

As the tendon gallery is located entirely within the NI common basemat, it is analyzed and designed as a part of the common basemat. The codes and standards, loads and load combinations, design and analysis procedures, and structural materials for the tendon gallery are the same as those for the NI common basemat, and are described in DCD Subsections 3.8.5.2 through 3.8.5.4, 3.8A.1.2.1, 3.8A.1.2.3, and 3.8A.1.4.2. For the analysis model, design section forces and design results of the NI common basemat, including the tendon gallery, are presented in Tables 3.8A-5 through 3.8A-13 and Figures 3.8A-13 through 3.8A-17 of the DCD.

The RCB foundation reinforcement consists of top horizontal layers of reinforcement, bottom horizontal layers of reinforcement, and vertical shear reinforcing bars. The bottom layers of reinforcing bars are arranged in a rectangular pattern and the top layers of reinforcing bars are arranged in radial and hoop directions as shown in Figures 3.8A-16 and 3.8A-17. The reinforcement at the upper portion of the tendon gallery is in the radial and hoop directions, and the reinforcement at the lower portion of the tendon gallery is in the rectangular pattern aligned with the plant NS and EW directions as shown in Figures 3.8A-16 and 3.8A-17, and Table 3.8A-12.

Impact on DCD

DCD Tier 2, Subsection 3.8A.1.4.2 .1 will be revised as indicated in the attachment associated with this response.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

3.8A.1.4.2 Containment Basemat

3.8A.1.4.2.1 Description

The NI common basemat structure of the APR1400 consists of the auxiliary building (AB) area base and reactor containment building (RCB) area base structure. The NI common basemat is a reinforced concrete mat foundation that covers an area with maximum dimensions of 106.0 m × 107.6 m (348 ft × 353 ft). The thickness of basemat is 10 ft (El. 45 ft 0 in through El. 55 ft 0 in.) in the AB area and variable thickness of 23 ft to 33 ft (El. 45 ft 0 in through El. 78 ft 0 in.) in the RCB area in general, except partial areas such as the tendon gallery and reactor cavity area. The top of the basemat in the RCB is at El. 78 ft 0 in, whereas the basemat is at El. 66 ft 0 in in the reactor cavity area. The arrangements of the structure are shown in Figure 3.8A-11.

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The reactor containment basemat is reinforced at the top and bottom with layers of reinforcing steel bars. The reinforcing bars are arranged in the radial and hoop directions for top layers and in the orthogonal directions for bottom layers.

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3.8A.1.4.2.2 Load Combinations Considered

The following loading combinations are critical for the analysis and design of the basemat:

a. Test: $1.0D + 1.0L + 1.0L_h + 1.0F + 1.0P_t$

b. Normal: $1.0D + 1.0L + 1.0L_h + 1.0F$

c. Severe: $1.0D + 1.3L + 1.3L_h + 1.0F$

d. Abnormal: $1.0D + 1.0L + 1.0L_h + 1.0F + 1.5P_a$

e. Abnormal/Extreme: $1.0D + 1.0L + 1.0L_h + 1.0F + 1.0P_a + 1.0Y_r + 1.0E_s$

3.8A.1.4.2.3 Analysis and Design Procedures

The design of the APR1400 adheres to a standardized design concept and can be constructed on various sites, including rock site even soil site.

Among the nine soil profiles and one fixed-base condition, three profiles (Soil Profiles #1, #4, and #8) are considered. Soil Profiles #1, #4, and #8 denote weak, moderate, and strong soil properties, respectively.

<#1>

The NI common basemat includes a hollow rectangular toroid for the tendon gallery. The tendon gallery provides a space to install and inspect the inverted "U" shaped vertical tendons. It is located entirely within the NI reinforced concrete basemat, as shown in Figures 3.8-1 and 3.8-2. The vertical tendons run up the cylindrical shell, over the dome in a non-radial mesh pattern, run down to the tendon gallery on the opposite side, and are anchored at each end in the tendon gallery, as shown in Figure 3.8-4. As the tendon gallery is located entirely within the NI common basemat, it is analyzed and designed as a part of the common basemat. The codes and standards, loads and load combinations, design and analysis procedures, and structural materials for the tendon gallery are the same as those for the NI common basemat, and are described in Subsections 3.8.5.2 through 3.8.5.4, Subsections 3.8A.1.2.1 and 3.8A.1.2.3, and the following Subsections 3.8A.1.4.2.2 through 3.8A.1.4.2.4. For the analysis model, design section forces and design results of the NI common basemat, including the tendon gallery, are presented in Tables 3.8A-5 through 3.8A-13 and Figures 3.8A-13 through 3.8A-17.

<#2>

The reinforcement at the upper portion of the tendon gallery is in the radial and hoop directions, and the reinforcement at the lower portion of the tendon gallery is in the rectangular pattern aligned with the plant NS and EW directions as shown in Figures 3.8A-16 and 3.8A-17, and Table 3.8A-12.

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Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**255-8285**
SRP Section:	**03.08.05 - Foundations**
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Question No. 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 3.8.5.1, “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.

Response

APR1400 has a structural mat foundation referred to as common basemat for the reactor containment building (RCB) and the auxiliary building (AB). The bottom of the common basemat is not flat; the thickness of the mat varies partially, as shown in Figures 1-2 and 1-3 of Technical Report APR1400-E-S-NR-14006-P, Rev. 1. The variety of the thickness and shape is a result from the arrangement of the structures, systems, and components.

The partial concave and convex areas of the basemat may be expected to play a role as shear keys against sliding in the basemat’s stability check. Horizontal shears, such as those produced by earthquakes, can be transferred to the subgrade by shear keys as well as by friction along the bottom of the basemat. Nevertheless, in the stability check for sliding resistance of the basemat, the effects of the shear keys are conservatively neglected. Only the basemat friction force is considered to resist the sliding of the common basemat.

In the structural analysis of the common basemat, the concave and convex areas are modeled as shown in Figure 3-5 of the Technical Report APR1400-E-S-NR-14006-P, Rev. 1. Therefore, the shear key areas are analyzed and designed as a part of the basemat. The design of the shear key areas is performed in accordance with the design of the rest of the basemat.

Similarly, the foundation of the diesel fuel oil tank (DFOT) room is an underground structure with two small sumps, as shown in Figures A-2 and A-3 of the technical report. Although the sump parts are modeled in the structural analysis of the DFOT, as shown in Figure A-5 of the technical report, the shear key effect of the sumps is conservatively neglected in the sliding check.

DCD Tier 2, Subsection 3.8.5.5.2 will be revised to include the information in this response. Please refer to the attachment to the applicant's response to RAI 255-8285, Question 03.08.05-14.

Impact on DCD

DCD Tier 2, Subsection 3.8.5.5.2 will be revised to include the information in this response, as shown in the attachment to the applicant's response to RAI 255-8285, Question 03.08.05-14.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

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Docket No. 52-046

RAI No.:	**255-8285**
SRP Section:	**03.08.05 - Foundations**
Application Section:	**03.08.05**
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Question No. 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 3.8.5.1, “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.

Response

Waterproofing membranes are not used in the APR1400 design, as described in sentence “e” of DCD Tier 2, Section 3.4.1.2. Therefore, waterproofing membranes do not affect shear resistance of the NI common basemat.

The basemat design thickness is more than 2 ft, and it meets the requirement of protection against water seepage and penetrations below flood level in SRP 14.3.2.II.8. The concrete thickness of more than 2 ft is expected to provide the basemat with the waterproofing function without specific membranes or additional concrete thickness according to the SRP 14.3.2.II.8. This is also described in the sentence “e” of DCD Tier 2, Section 3.4.1.2.

Moreover, as stated in COL3.8(3), the COL applicant is to determine the environmental condition associated with the durability of concrete structures and provide the concrete mix design that prevents concrete degradation including the reactions of sulfate and other chemicals, corrosion of reinforcing bars, and the influence of reactive aggregates.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

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Docket No. 52-046

RAI No.:	**255-8285**
SRP Section:	**03.08.05 - Foundations**
Application Section:	**3.8.5**
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Question No. 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:

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.

Response

APR1400 has a structural mat foundation referred to as common basemat for the reactor containment building (RCB) and the auxiliary building (AB). The design basis of the foundation below the RCB and the AB conform to the requirements of ASME Section III, Division 2, Subsection CC and ACI 349 codes, respectively. The codes’ jurisdiction and their application, including loads and load combinations between the two codes, have been studied. As the design criteria for the two different portions of the commom basemat are different, the application of load for the basemat is divided into two parts. For this, the response to RAI 199-8223, Question 03.08.01-11 can be referred.

The details of loads and load combinations are described in DCD Tier 2, Subsections 3.8.1.3 and 3.8.4.3, and Tables 3.8-2 and 3.8-9A for the two codes.

The ACI 349 code concentrates on the requirements as one of the concrete structures in a nuclear power plant with ultimate strength design concept. On the other hand, the ASME code describes the requirements with more focus on the functionality of containment with allowable stress approach. The load factors in Tables 3.8-2 and 3.8-9A are based on these design concepts according to the two codes. Therefore, it is difficult to say that one of the codes is always conservative or always produces adverse design results. Since they each have different philosophies and design methods as well as different loads and load combinations, it is important to distinguish their design concepts and application scope.

For the code application scope and jurisdiction boundary of the NI common basemat, refer to Subsection 3.8.1.1.2 and Figure 3.8-26, as provided in the attachment associated with the response to RAI 199-8223, Question 03.08.01-11. In the design of the concrete common basemat of the APR1400, ASME CC and ACI 349 codes are applied to the portion below the RCB and below the AB, respectively. At the interface between the two codes, the larger amount of reinforcement required by either code is used, as described in the response to RAI 199-8223, Question 03.08.01-11.

Impact on DCD

DCD Tier 2, Subsection 3.8.5.3 will be revised as indicated in the attachment associated with this response.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

The auxiliary building basemat is reinforced at the top and bottom with layers of reinforcing steel bars. The reinforcing bars are arranged in orthogonal directions for the top and bottom layers.

3.8.5.1.3 Emergency Diesel Generator Foundations

The emergency diesel generator (EDG) building block comprises two buildings, one of which houses the EDGs and the other the diesel fuel oil tank (DFOT). The two buildings are independent structures built on a separate concrete reinforced mat foundation with a thickness of 1.2 m (4 ft). The bottom of the basemat is located at elevation 92 ft 0 in for the EDG building and elevation 59 ft 0 in for the DFOT building.

3.8.5.2 Applicable Codes, Standards, and Specifications

The reinforced concrete foundations of the reactor containment building are designed using the codes and standards described in Subsection 3.8.1.2. The reinforced concrete foundations and supports of other seismic Category I structures are designed using the codes and standards described in Subsection 3.8.4.2.

3.8.5.3 Loads and Load Combinations

The design loads and load combinations of the reactor containment building foundation are described in Table 3.8-2. The design loads and load combinations of the auxiliary building foundation and EDG building foundation are described in Subsection 3.8.4.3.

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Subsection 3.8.1.3 and

and Table 3.8-9A

3.8.5.4 Design and Analysis Procedures

The NI common basemat is analyzed using the ANSYS computer program. Stiffening effects of the reactor containment building wall, internal concrete structures, and auxiliary building are included in the model.

The NI common basemat is modeled with eight-node solid element in the ANSYS computer program. In addition, in order to consider the soil effect, the link element in ANSYS is used with the NI common basemat model.

The analysis and design of the foundation below the reactor containment building conform to the requirements of ASME Section III,Division 2, Subsection CC. The analysis and design code for the foundations below the auxiliary building and EDG building is ACI 349. As the design criteria are different, the applications of loads and load combinations for the foundations are in accordance with each code. While the ACI 349 code concentrates on the requirements as one of the concrete structures in a nuclear power plant, the ASME code describes the requirements with more focus on the functionality of containment. The load factors in Tables 3.8-2 and 3.8-9A are based on these design concepts according to the two codes. For the code application scope and jurisdiction boundary of the NI common basemat, refer to Subsection 3.8.1.1.2 and Figure 3.8-26.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

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SRP Section:	**03.08.05 – Foundations**
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Question No. 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.

Response

1. DCD Tier 1 Section 2.2.2.1 describes that the EDG building block includes the EDG building and the DFOT building. DCD Tier 1 Table 2.2.2-2 provides the ITAAC items for the EDG building block. Therefore, DCD Tier 1 Table 2.2.2-2 will be revised to clarify the DFOT building is included in the EDG building block.

2. ITAAC Items of the essential service water building and the component cooling water heat exchanger building are provided in KHNP's response to RAI 88-8046, Question 03.05.02-6. The response includes the requirement to verify the buildings are designed and constructed to withstand the structural design basis loads, as noted in COL 3.8(1) in Section 3.8.6 of APR1400 DCD Tier 2.

Impact on DCD

DCD Tier 1, Table 2.2.2-2 will be revised as indicated in the attachment associated with this response.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

LIST OF TABLES

Block(1)

building block

Table 2.2.2-2

Emergency Diesel Generator Building ITAAC

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
1. The basic configuration of the EDG building block is as shown in Figures 2.2.2-1 and 2.2.2-2.	1. Inspection of the basic configuration of the as-built EDG building block will be conducted.	1. The EDG building block conforms with the basic configuration as shown in Figures 2.2.2-1 and 2.2.2-2.
2. The EDG building block is designed and constructed to withstand the structural design basis loads.	2. A structural analysis will be performed to reconcile the as-built EDG structure with the structural design basis loads.	2. A report exists and concludes that the EDG building block can withstand the structural design basis loads.
3. The key dimensions of the EDG building block are as described in Table 2.2.2-1.	3. Inspection will be performed to verify that the as-built wall and slab thickness conform to the structural configuration.	3. A report exists and concludes that the EDG building block as-built wall and slab thickness conform with the structural configuration as described in Table 2.2.2-1.

(1) EDG building block includes EDG building and DFOT building.

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Question No. 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.

Response

According to SRP Section 3.8.5.II.4.E, the settlement was evaluated as follows:

(1) Effects of static and dynamic differential settlement

To evaluate the static differential settlement, the static load (D+L) was applied to the NI common basemat model. The differential settlements were computed based on a distance of approximately 50ft between two nodes. DCD Tier 2, Table 3.8A-17 shows the summary of the differential settlement in the NI basemat, and Figure 3.8A-18 shows the node locations at the bottom of the NI common basemat.

For differential settlement by seismic load, the displacement results from the seismic analysis (SASSI) are used. The relative displacements were considered in all time steps at 50 selected nodes. DCD Tier 2, Figures 4-6 through 4-14 show the relative displacement in selected nodes at the time computed for the maximum and minimum displacement of all time steps.

(2) Short term and long term

Short term settlement is evaluated as a construction sequence analysis. Therefore, the detailed analysis will be accomplished corresponding to the actual construction sequence using the same methodology described in DCD Tier 2, Section 3.8.5.4. The response to RAI 255-8285, Question 03.08.05-7 will perform a detailed construction sequence analysis to determine effects on settlement.

Long term settlement is evaluated by assuming long duration loads acting during the entire life of the plant. Change in the soil spring parameter to account for time dependent effects are not considered because the site specific soil conditions are not available. This is related with DCD COL item, COL 3.8(7).

(3) Effect of soil type

Three generic site soil profiles (S1: Soft, S4: Medium, S8: Hard) are used to consider the effects of soil conditions on settlement. The selected profiles have been chosen to be a representative sample.

(4) Effect of foundation type and size

The 3D FE NI common basemat model with superstructure was developed to consider the effect of actual foundation size and shape. The FE NI common basemat model is shown in DCD Tier 2, Figure 3.8A-12.

According to SRP Section 3.8.5.II.4.G, an evaluation of stiff and soft spots should be considered in analysis of the basemat. The stiff and soft spots are not predictable before the site survey or site excavation for the specific site. So, if these are found during excavation, the COL applicant shall perform basemat analysis considering stiff and soft spots (DCD COL item, COL 3.8(11)) or the soft spots must be excavated and backfilled with a substance which prevents additional effects and uncertainty such as differential settlement.

According to SRP Section 3.8.5.II.4.J, the evaluation of settlement during the construction sequence will be performed corresponding to the actual construction sequence using the same methodology described in DCD Tier 2, Section 3.8.5.4 (Please refer to Question 03.08.05-7). If the actual soil status and loss of cement from the mud mat is expected after the site survey or site excavation, loss of subgrade contact due to loss of cement from a mud mat is considered corresponding to the actual site status (DCD COL item, COL 3.8(12)). The detailed analysis will be performed using the same methodology described in DCD Tier 2, Section 3.8.5.4.

The evaluation of settlement which satisfies the criteria of SRP Section 3.8.5.II.4.K will be completed until March 31, 2016. The evaluation will consider the consistency between soil stiffness and the magnitude of soil strains used in the SSI analysis, the dishing or Boussinesq effects, and will include a comparison between toe bearing pressure used in the foundation design and the toe bearing pressure obtained from the SSI analysis. Upon completion of the analysis, TeR APR1400-E-S-NR-140006 will be revised.

Impact on DCD

DCD Tier 2, Table 1.8-2 and Subsection 3.8.6 will be revised as indicated in the attachment associated with this response.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

Technical report APR1400-E-S-NR-14006-P/NP will be revised by March 31, 2016.

Table 1.8-2 (5 of 29)

Item No.	Description
COL 3.8(7)	The COL applicant is to confirm that uneven settlement due to construction sequence of the NI basemat falls within the values specified in Table 2.0-1.
COL 3.8(8)	The COL applicant is to provide the necessary measures for foundation settlement monitoring considering site-specific conditions.
COL 3.8(9)	The COL applicant is to provide testing and inservice inspection program to examine inaccessible areas of the concrete structure for degradation and to monitor groundwater chemistry.
COL 3.8(10)	The COL application is to provide the following soil information for APR1400 site: 1) Elastic shear modulus and Poisson's ratio of the subsurface soil layers, 2) Consolidation properties including data from one-dimensional consolidation tests (initial void ratio, Cc, Ccr, OCR, and complete e-log p curves) and time-versus-consolidation plots, 3) Moisture content, Atterberg limits, grain size analyses, and soil classification, 4) Construction sequence and loading history, and 5) Excavation and dewatering programs.
COL 3.9(1)	The COL applicant is to provide the inspection results for the APR1400 reactor internals classified as non-prototype Category I in accordance with RG 1.20.
COL 3.9(2)	The COL applicant is to provide a summary of the maximum total stress, deformation, and cumulative usage factor values for each of the component operating conditions for ASME Code Class 1 components except for ASME Code Class 1 nine major components. For those values that differ from the allowable limits by less than 10 percent, the contribution of each loading category (e.g., seismic, deadweight, pressure, and thermal) to the total stress is provided for each maximum stress value identified in this range. The COL applicant is to also provide a summary of the maximum total stress and deformation values for each of the component operating conditions for Class 2 and 3 components required to shut down the reactor or mitigate consequences of a postulated piping failure without offsite power (with identification of those values that differ from the allowable limits by less than 10 percent).
COL 3.9(3)	The COL applicant is to identify the site-specific active pumps.
COL 3.9(4)	The COL applicant is to confirm the type of testing and frequency of site-specific pumps subject to IST in accordance with the ASME Code.
COL 3.9(5)	The COL applicant is to confirm the type of testing and frequency of site-specific valves subject to IST in accordance with the ASME Code.
COL 3.9(6)	The COL applicant is to provide a table listing all safety-related components that use snubbers in their support systems.

COL.3.8 (11) The COL applicant is to perform a foundation evaluation including stiff and soft spots using the methodology described in DCD Tier 2, Section 3.8.5.4.

COL. 3.8 (12) The COL applicant is to evaluate the loss of subgrade contact due to loss of cement from the mud mat using site specific data and the methodology described in DCD Tier 2, Section 3.8.5.4.

COL 3.8(7) The COL applicant is to confirm that uneven settlement due to construction sequence of the NI basemat falls within the values specified in Table 2.0-1.

COL 3.8(8) The COL applicant is to provide the necessary measures for foundation settlement monitoring considering site-specific conditions.

COL 3.8(9) The COL applicant is to provide testing and inservice inspection program to examine inaccessible areas of the concrete structure for degradation and to monitor groundwater chemistry.

COL 3.8.(10) The COL applicant is to provide the following soil information for the APR1400 site: 1) elastic shear modulus and Poisson's ratio of the subsurface soil layers, 2) consolidation properties including data from one-dimensional consolidation tests (initial void ratio, Cc, Ccr, OCR, and complete e-log p curves) and time-versus-consolidation plots, 3) moisture content, Atterberg limits, grain size analyses, and soil classification, 4) construction sequence and loading history, and 5) excavation and dewatering programs.

COL.3.8 (11) The COL applicant is to perform a foundation evaluation including stiff and soft spots using the methodology described in DCD Tier 2, Section 3.8.5.4.

COL. 3.8 (12) The COL applicant is to evaluate the loss of subgrade contact due to loss of cement from the mud mat using site specific data and the methodology described in DCD Tier 2, Section 3.8.5.4.

3.8.7 References

1. 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," U.S. Nuclear Regulatory Commission.

2. ASME Section III, Subsection NE, "Class MC Components," The American Society of Mechanical Engineers, the 2007 Edition with the 2008 Addenda.

3. ASME Section III, Division 2, "Code for Concrete Containments," Subsection CC, American Society of Mechanical Engineers, 2001 Edition with 2003 Addenda.

4. Regulatory Guide 1.35, "Inservice Inspection of Ungrouted Tendons in Prestressed Concrete Containment," Rev. 3, U.S. Nuclear Regulatory Commission, July 1990.

5. Regulatory Guide 1.35.1, "Determining Prestressing Forces for Inspection of Prestressed Concrete Containments," U.S. Nuclear Regulatory Commission, July 1990.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**255-8285**
SRP Section:	**03.08.05 – Foundations**
Application Section:	**03.08.05**
Date of RAI Issue:	**10/19/2015**

Question No. 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.

Response

For the differential settlements of the EDG & DFOT basemat, the static load (dead and live load) is applied. The location of nodes used to check the settlements are spaced approximately 50 ft apart. Figures 1 and 2, below, show descriptions and node locations at the bottom of the EDG & DFOT basemat. In addition, these figures will be added to DCD Appendix 3.8A as shown in the attachment to this response. The differential settlement for the EDG & DFOT is summarized in DCD Tier 2, Table 3.8A-39.

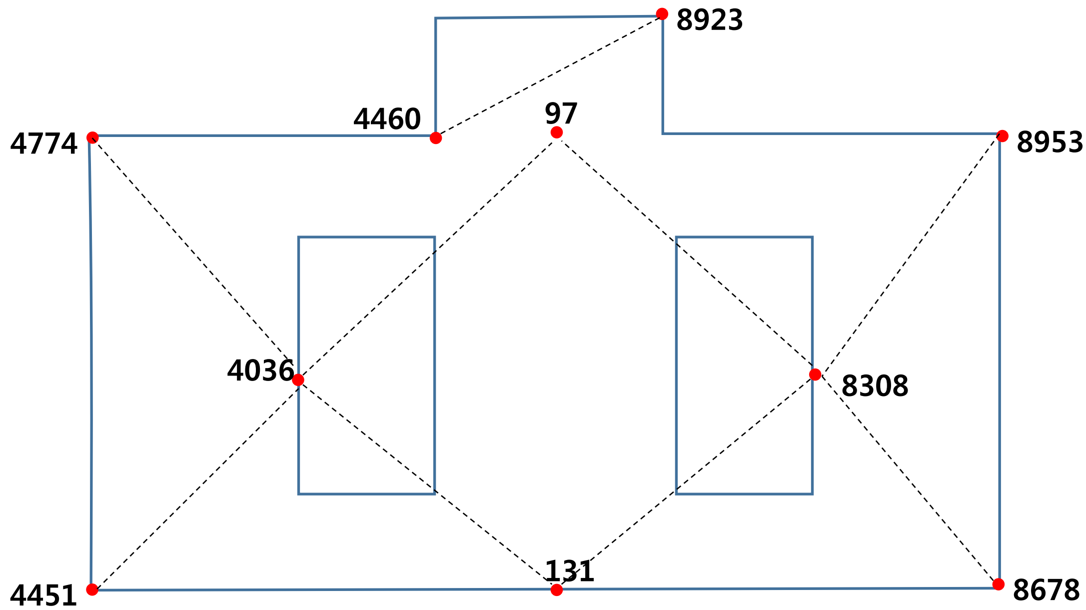

Figure1 Node Locations at EDG Basemat for checking settlements (Static)

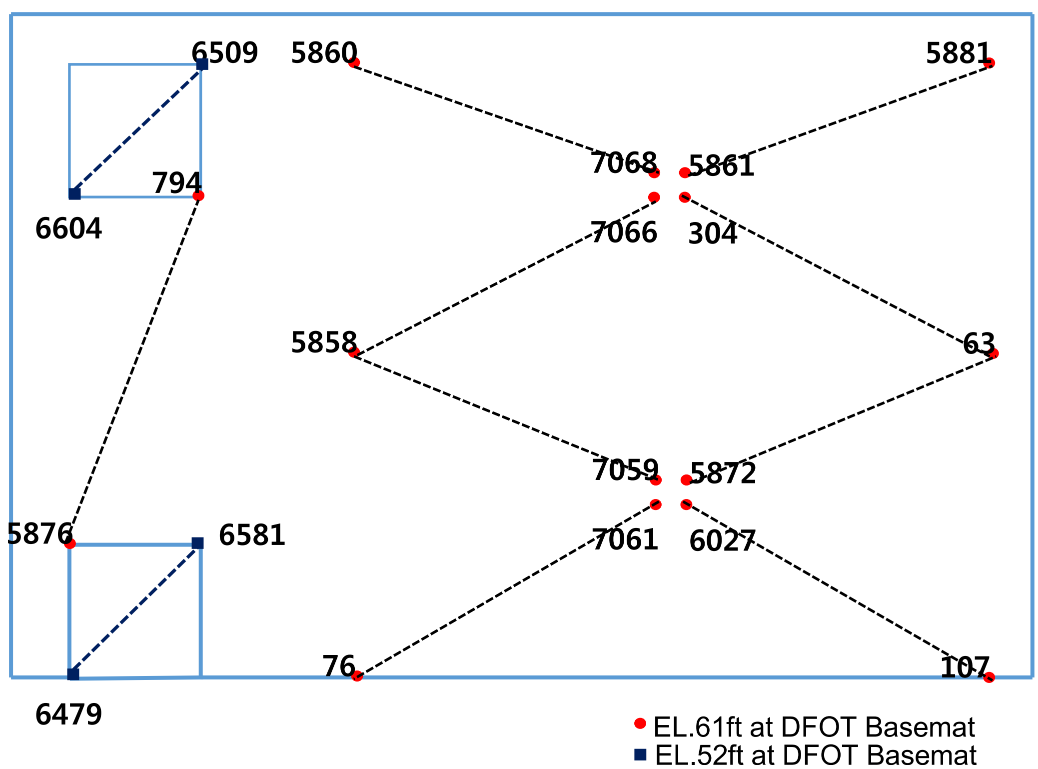

Figure2 Node Locations at DFOT Basemat for checking settlements (Static)

Impact on DCD

Subsection 3.8.A.3.4.1 will be revised and Figures 3.8.A-57 and 58 will be added, as indicated in the attached markup.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

The normal design ground water elevation is EL. 96 ft 8 in. The extreme ground water elevation is the same as plant grade level (EL. 98 ft 8 in.) considering probable maximum flood.

In the earthquake load, axial force, shear force, and moment due to horizontal and vertical excitation of the structure are obtained from seismic analysis. Since seismic load governs over wind load, stability checks are not considered under wind load. A summary of overturning, sliding, and flotation check is shown provided in Table 3.8A-38.

Settlement Check

Differential settlements are divided by the differential settlement within the EDG building basemat and the differential settlement within DFOT building. For the differential settlements within the each basemat, the static (dead and live loads) loading case is calculated.

The nodes within a distance of approximately 15.24 m (50 ft) are selected to check the different settlement. Table 3.8A-39 shows the differential settlements at site profiles 1, 4, and 8.

Figure 3.8A-57 and Figure 3.8A-58 show the node locations at the bottom of the EDG & DFOT basemat for checking the settlements. The analysis of multiple of settlements (long and short term) will use these nodes.

3.8A.3.4.2 Shear Walls

Description

The shear walls and slabs of the EDG building representing the primary lateral load-resisting system are designed against seismic or extreme wind-related loads. The concrete slab distributes lateral forces through diaphragm action to the shear walls as in-plane loads in proportion to the relative stiffness of the shear walls. These in-plane shear forces are transferred down to the basemat foundation as in-plane shear forces and moments of the shear walls.

The in-plane shear forces and moments, which are obtained from the seismic analysis results, are combined with the applicable out-of-plane loads to determine the quantity and distribution of vertical and horizontal reinforcing steel of the EDG building shear walls.

add

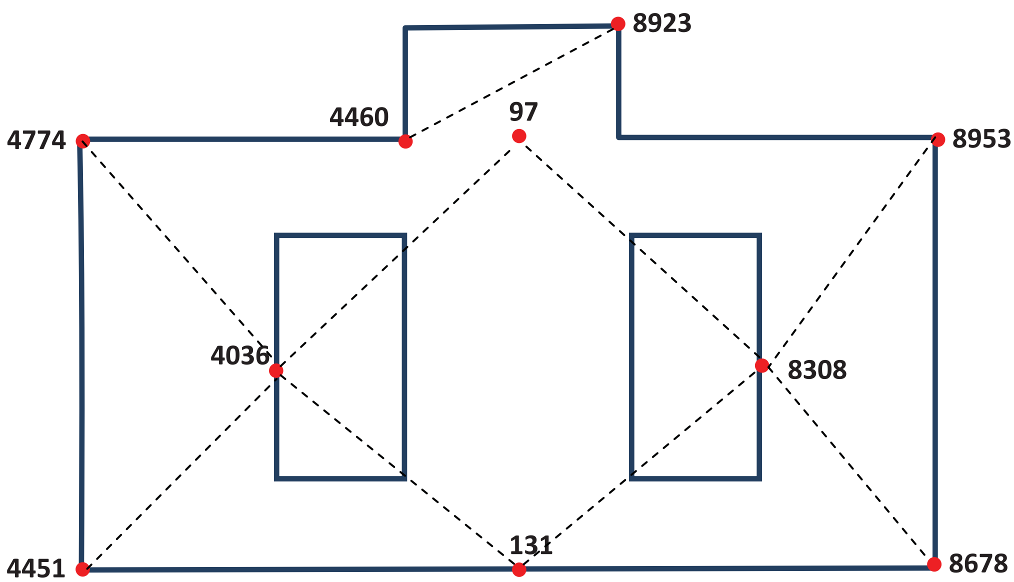

Figure 3.8A-57 Node Locations at EDG Basemat for Checking Settlements (Static)

add

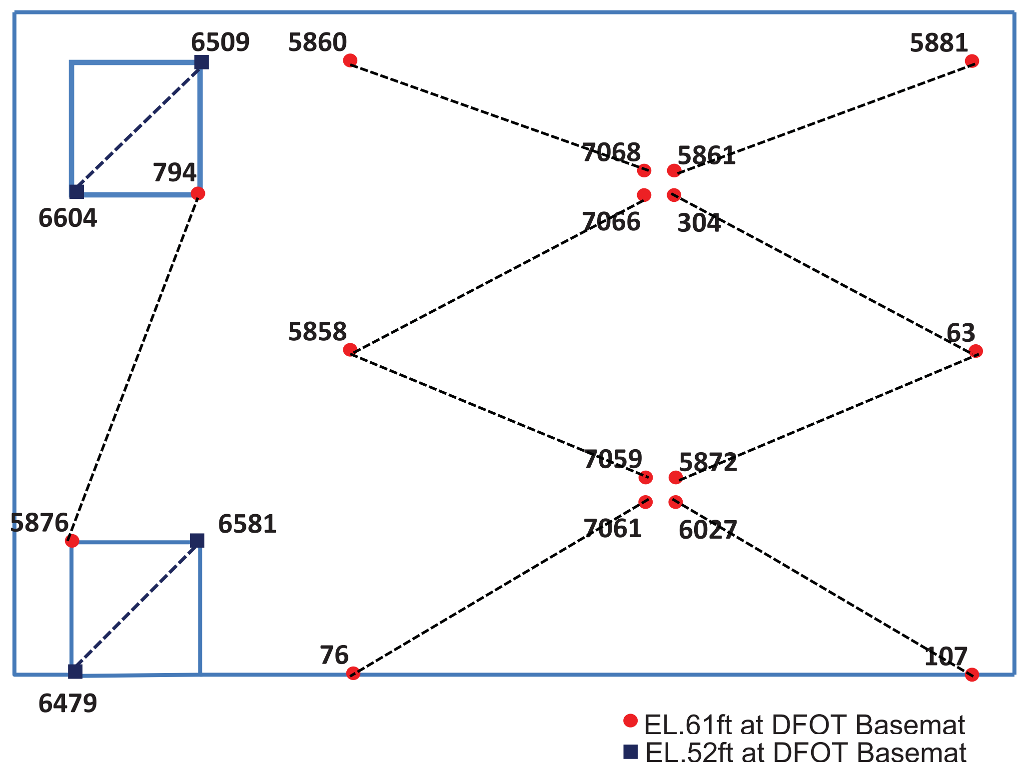

Figure 3.8A-58 Node Locations at DFOT Basemat for Checking Settlements (Static)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**255-8285**
SRP Section:	**03.08.05 – Foundations**
Application Section:	**03.08.05**
Date of RAI Issue:	**10/19/2015**

Question No. 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.

Response

Load combinations and load factors for the RCB and the AB basemats are selected based on their relevant design codes, ASME and ACI respectively. The boundary of code jurisdiction between the ASME code and the ACI code is shown in Figure 1. The details of the code jurisdiction boundary are presented in the response to RAI 199-8223, Question 03.08.01-11.

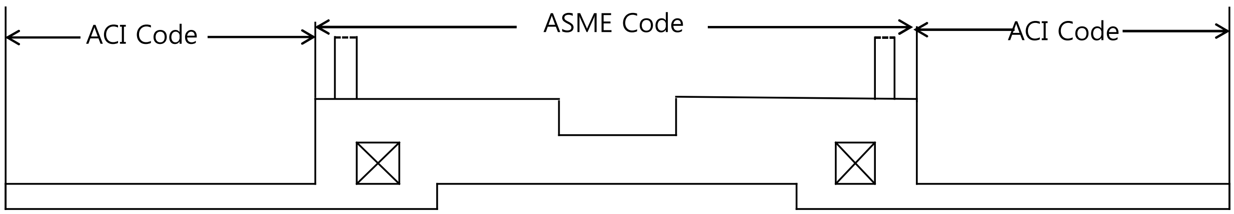

Figure 1 Jurisdictional Boundary for Design of Common Basemat

For the RCB basemat, the 5 loading combinations (test, normal, severe, abnormal, and abnormal/extreme environmental) are selected as the critical loading combinations in the analysis of the NI basemat. Table1 shows the selected load combinations and applicable load factors for anlaysis.

As shown in Table 1, the loads, except for loads G, To, Ta, W, Ro, Ra, Yj, Ym and Pv, are considered in the basemat analysis. The polar crane load includes the self-weight and lifted loads in the basemat analysis.

- Valve actuation load (G), due to POSRV discharge, is a short transient pressure in expansion and collapse of the air bubble. The load from the spargers is locally applied in the IRWST. The load does not effect on the global behavior of the basemat. Based on the explanation above, this load was not considered in the basemat analysis.

- According to ACI 349, thermal gradients less than approximately 100°F need not be analyzed because such gradients will not cause significant stress in the reinforcement or strength deterioration. The effects of the temperature load in the basemat are negligible and not considered in the basemat analysis because the temperature gradient is approximately 50°F.

- Wind (W) and tornado (Wt) loads are not considered. From the loading conditions, wind and tornado loads are not considered simultaneously with the seismic load. A comparison of the loads shows the seismic load is larger than the wind and tornado loads.

- The reactions of piping, cable trays (Ro, Ra), jet impingment load (Yj), and missile impact load (Ym) are considered in local analyses.

- The external pressure load (Pv) in the normal loading condition is negligible compared with the accident pressure (Pa) in the abnormal loading condition. So, it does not effect on global behavior of the basemat.

For the AB basemat, the 4 loading combinations (test, normal, abnormal, and abnormal/extreme environmental) are selected as the critical loading combinations in the analysis of the NI basemat. Table 2 shows the selected load combinations and applicable load factors for the anlaysis.

As shown in Table 2, the loads, except for loads Ra, To, Po, Mo, Pa, Ta and Ma which do not have an effect on the global behavior of the basemat, are considered in the basemat analysis. For the crane and trolley loads, the self-weight of the fuel handling overhead crane is considered in the basemat analysis.

Additionally, the seismic load is conservatively divided into 8 cases to account for each superstructure's behavior. Therefore, the load combinations are summarized in technical report (TR) APR1400-E-S-NR-14006-P, Rev 1, “Stability Check for NI Common Basemat,” Table 3-5.

For the design of the basemat, at the interface between the ASME and ACI codes, the lager amount of reinforcement required by either code was used.

Table 1 Selected Loading Conditions of Superstructures for Basmat Analysis (RCB)

Loading Condition	D	L	F	Pt	G	Pa	Tt	To	Ta	Es	W	Wt	Ro	Ra	Yr	Yj	Ym	Yf	H	Hs	Pv	Ha	Ps	Analysis
Test	1.0	1.0	1.0	1.0	-	-	(1.0)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	yes
Construction	1.0	1.0	1.0	-	-	-	-	1.0	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	no(①)
Normal	1.0	1.0	1.0	-	(1.0)	-	-	(1.0)	-	-	-	-	(1.0)	-	-	-	-	-	-	-	(1.0)	-	-	yes
Severe Environmental	1.0	1.3	1.0	-	(1.0)	-	-	(1.0)	-	-	(1.5)	-	(1.0)	-	-	-	-	-	-	-	(1.0)	-	-	yes
	1.0	1.3	1.0	-	1.0	-	-	1.0	-	-	-	-	1.0	-	-	-	-	-	1.5	-	1.0	-	-	no(②)
Extreme Environmental	1.0	1.0	1.0	-	1.0	-	-	1.0	-	1.0	-	-	1.0	-	-	-	-	-	-	-	1.0	-	-	no(③)
	1.0	1.0	1.0	-	1.0	-	-	1.0	-	-	-	1.0	1.0	-	-	-	-	-	-	-	1.0	-	-	no(④)
	1.0	1.0	1.0	-	1.0	-	-	1.0	-	-	-	-	1.0	-	-	-	-	-	-	1.0	1.0	-	-	no(⑤)
Abnormal	1.0	1.0	1.0	-	(1.0)	1.5	-	-	(1.0)	-	-	-	-	(1.0)	-	-	-	-	-	-	-	-	-	yes
	1.0	1.0	1.0	-	1.0	1.0	-	-	1.0	-	-	-	-	1.25	-	-	-	-	-	-	-	-	-	no(⑥)
	1.0	1.0	1.0	-	1.25	1.25	-	-	1.0	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	no(⑦)
Abnormal/Severe Environmental	1.0	1.0	1.0	-	1.0	1.25	-	-	1.0	-	1.25	-	-	1.0	-	-	-	-	-	-	-	-	-	no(⑧)
	1.0	1.0	1.0	-	1.0	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	-	no(⑨)
	1.0	1.0	1.0	-	1.0	-	-	1.0	-	-	1.0	-	-	-	-	-	-	-	-	-	-	1.0	-	no(⑩)
Abnormal/Extreme Environmental	1.0	1.0	1.0	-	(1.0)	1.0	-	-	(1.0)	1.0	-	-	-	(1.0)	1.0	(1.0)	(1.0)	-	-	-	-	-	-	yes
Severe Accident	1.0	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	no

* ( ) : load not considered in basemat analysis. * yellow column : considered load combination in basemat analysis.

① - Effect on the basemat due to wind is less than that of Pt, and To is negligible

② - H is not considered to be critical for the basemat (Containment building roof could not contain any rainwater.)

③, ④, ⑤ - Abnormal/ Extreme Environmental combination is more limiting than these combinations.

⑥ - 0.25 x Ra is less critical than 0.5 x Pa for the basemat

⑦, ⑧ - 0.25 x G and W are less critical than 0.25 x Pa for the basemat

⑨, ⑩ - 1.0 x W is less critical than 1.25 x Pa for the basemat

Table 2 Selected Loading Conditions of Superstructures for Basmat Analysis (AB)

Loading Condition	Normal									Severe		Abnormal					Extreme			Analysis
	D	D_d	L	L_h	T_o	R_o	C	P_o	M_o	W	H	P_a	T_a	R_a	Y	M_a	E_s	W_t	H_s	
Construction	1.1	-	1.3	1.1	-	1.1	1.3	-	1.3	1.6	-	-	-	-	-	-	-	-	-	no(①)
	-	0.9	-	1.1	-	-	1.3	-	1.3	1.6	-	-	-	-	-	-	-	-	-	no(②)
Test	1.1	-	1.3	1.1	(1.3)	(1.1)	1.3	(1.3)	(1.3)	-	-	-	-	-	-	-	-	-	-	yes
Normal	1.4	-	1.7	1.4	(1.3)	(1.4)	1.7	(1.7)	(1.7)	-	-	-	-	-	-	-	-	-	-	yes
Severe Environmental	1.4	-	1.7	1.4	1.3	1.4	1.7	1.7	1.7	1.7	-	-	-	-	-	-	-	-	-	no(③)
	1.2	-	-	1.4	1.3	1.2	1.7	1.7	1.7	1.7	-	-	-	-	-	-	-	-	-	no(④)
	1.4	-	1.7	1.4	1.3	1.4	1.7	1.7	1.7	-	1.7	-	-	-	-	-	-	-	-	no(⑤)
	1.2	-	-	1.4	1.3	1.2	1.7	1.7	1.7	-	1.7	-	-	-	-	-	-	-	-	no(⑥)
Abnormal	1.0	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-	-	-	-	-	-	1.0	-	-	-	no(⑦)
	1.0	-	1.0	1.0	-	-	1.0	-	(1.0)	-	-	(1.4)	(1.0)	(1.0)	-	-	-	-	-	yes
Extreme Environmental	1.0	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-	-	-	-	-	-	-	1.0	-	-	no(⑧)
	1.0	-	1.0	1.0	1.0	1.0	-	1.0	1.0	-	-	-	-	-	-	-	-	1.0	-	no(⑨)
	1.0	-	1.0	1.0	1.0	1.0	-	1.0	1.0	-	-	-	-	-	-	-	-	-	1.0	no(⑩)
Abnormal / Extreme Environmental	1.0	-	1.0	1.0	-	-	1.0	-	(1.0)	-	-	(1.0)	(1.0)	(1.0)	(1.0)	(1.0)	1.0	-	-	Yes

* ( ) : load not considered in basemat analysis. * yellow column : considered load combination in basemat analysis.

①, ② - Governed by the severe environmental load combination

③ - It is the same as Normal loading condition except wind load which is not critical in basemat design.

④ - Governed by the severe environmental load combination

⑤, ⑥ - H is not considered critical for the basemat

⑦, ⑧, ⑨, ⑩ - Abnormal/Extreme Environmental combination is more critical than these combinations

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**255-8285**
SRP Section:	**03.08.05 - Foundations**
Application Section:	**03.08.05**
Date of RAI Issue:	**10/19/2015**

Question No. 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.

Response

In the design of the APR1400, the stability check against sliding of Seismic Category I structures is based on the factor of safety specified in Table 3.8-10 of the DCD. From the calculation of the maximum horizontal shear force that can induce sliding of the foundation, the maximum shears induced by the safe shutdown earthquake were greater than those calculated by the wind load. Therefore, the wind load is not considered in the calculation for the sliding check, since the seismic force and the wind load are not in the same load combination.

Although the bottom face of the foundation may not be flat and partial concave and convex areas of the foundation are expected to play a role as shear keys, the shear key effect is conservatively neglected in the calculation for the sliding check.

In addition, the probable adverse effect of buoyancy from groundwater is considered in the calculation by subtracting the buoyant force from the dead weight of the structure.

As a result, the factor of safety against sliding is calculated by the ratio of the minimum sliding resistant force by base friction to the maximum driving shear force by the earthquake, as shown in the equation of Subsection 3.8.5.5.2 of the DCD.

In the calculation of the resistant force, the friction coefficient of 0.7 and the effective dead weight of the structure are multiplied. The coefficient of 0.7 is based on Design Manual 7.02, "Foundations and Earth Structures" of Naval Facility Engineering Command, and Provision 11.7.4.3 of ACI 349. In the design of the APR1400, there is a lean concrete layer between the supporting medium (soil or rock) and the foundation concrete. Waterproofing membranes are not used, as described in sentence "e" of DCD Tier 2, Section 3.4.1.2. Therefore, sliding by shear transfer may be considered across an interface between dissimilar materials, i.e., foundation concrete on lean concrete, and lean concrete and the supporting medium (soil or rock), and within the supporting medium.

According to DCD Tier 2, Table 2.0-1 and KHNP's response to RAI 149-8147, Question 02.05.04-12, the minimum angle of internal friction of supporting medium is 35 degrees, which leads to a friction coefficient of 0.7, and this is to be confirmed by the COL applicant (COL 2.5(15)). This value is applicable to the internal friction of the supporting medium, i.e., soil-on-soil interface. For the case of a cohesionless soil site, the COL applicant should confirm that the soil below the structures will have a friction angle in excess of 35 degrees. For a cohesive soil site, the COL applicant should confirm that the soil will have an undrained strength equivalent to or exceeding a drained strength of 35 degrees, yielding a friction coefficient greater than 0.7.

In addition, Design Manual 7.02 of Naval Facility Engineering Command (1986) states the friction coefficient is 0.7 between mass concrete on rock media, representing the friction angle of 35 degrees. This is applicable to the interface between the lean concrete and supporting medium at a rock site. The friction between the lean concrete and the supporting medium will be higher than soil-on-soil friction because the lean concrete will interlock with the soil or rock. The COL applicant is to verify that the friction coefficient at the site is bounded by the DCD value of 0.7. (COL 3.8(13)).

The Provision 11.7.4.3 of ACI 349 states that the friction coefficient shall be taken as 1.0 for concrete placed against hardened concrete with surface intentionally roughened. This is applicable to the interface between the foundation concrete and the lean concrete, and friction coefficient of 0.7 is conservative.

In the calculation of the resistant force, the uplifting effect of the vertical seismic component was not taken into account. Assuming 40% of maximum vertical seismic force is applied upward simultaneously with the maximum horizontal seismic force, the factor of safety for the sliding of NI common basemat is reduced from 1.51 to 1.26, which still exceeds the acceptable value of 1.1 in Table 3.8-10.

Impact on DCD

DCD Tier 2, Subsections 3.8.5.5.2, 3.8.6, and Table 1.8-2 will be revised, as indicated in the attachment associated with this response.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

The acceptance criteria for overturning, sliding, and flotation are described in Table 3.8-10. The factor of safety to design load combinations is calculated as stated below and compared to the minimum factors to provide reasonable assurance of the stability of the basemats.

3.8.5.5.1 Overturning Acceptance Criteria

The factor of safety against overturning is identified as the ratio of the resisting moment on overturning (M_r) to the overturning moment (M_o). Therefore,

FS_o = [M_r / M_o], not less than the factor of safety determined from Table 3.8-10.

Where:

FS_o = structure factor of safety against overturning caused by the design ba sis wind, tornado, hurricane, or earthquake load

M_r = resisting moment determined as the dead load of the structure minus buoyant force from normal design groundwater table, multiplied by the distance from the structure edge to the structure center of gravity p rovided there is no overstress at the edge of the structure

M_o = overturning moment caused by earthquake

Resistance moment due to passive soil pressure is not included in M_r. Therefore, active and overburden soil pressures are also not considered.

3.8.5.5.2 Sliding Acceptance Criteria

The factor of safety against sliding caused by earthquake is identified by the following ratio:

FS_s = [F_s]/[F_d], not less than the factor of safety determined from Table 3.8-10

Where:

FS_s = structure factor of safety against sliding caused by earthquake

F_s = sliding resistance along bottom of the basemat determined as the dead load of the structure minus the buoyant force from the normal design groundwater table

F_d = earthquake load

Replace : next page

~~The sliding resistance is based on the friction force developed between the basemat and the foundation with a coefficient of friction of 0.7 calculated with an internal friction angle of 35 degrees in the soil below the basemat. Resistance force due to passive soil pressure is not included in F_s. Therefore, active and overburden soil pressures are also not considered.~~

3.8.5.5.3 Flotation Acceptance Criteria

The factor of safety against flotation is identified as the ratio of the total dead load of the structure including basemat (D_r) to the buoyant force (F_b). Therefore, $FS_f = D_r / F_b$, not less than the factor of safety determined from Table 3.8-10.

Where:

FS_f = structure factor of safety against flotation caused by the maximum design basis flood or groundwater table

D_r = total dead load of the structure including basemat

F_b = buoyant force caused by the design basis flood or high groundwater table, whichever is greater

3.8.5.6 Material, Quality Control, and Special Construction Techniques

The materials, quality control, and special construction techniques for foundations conform with those set forth for the superstructures as discussed in Subsections 3.8.1.6 and 3.8.4.6 and Appendix 3.8A.

The COL applicant is to confirm that uneven settlement due to construction sequence of the NI basemat falls in the values specified in Table 2.0-1 (COL 3.8(7)).

3.8.5.7 Testing and Inservice Inspection Requirements

Testing and inservice surveillance of the basemat are performed in accordance with the requirements described in Subsections 3.8.1.7 and 3.8.4.7.

The COL applicant is to provide the necessary measures for foundation settlement monitoring considering site-specific conditions (COL 3.8(8)).

The sliding resistance is based on the minimum friction force between the sliding interfaces. Although the bottom face of the basemat may not be flat and partial concave and convex areas of the foundation are expected to play a role as shear keys, the shear key effect is conservatively neglected in the sliding check.

In the calculation of the resistant force, the friction coefficient of 0.7 is used. The coefficient of 0.7 is based on the minimum friction angle between the sliding interfaces being over 35 degrees. The friction between the lean concrete and the underlying soil or rock medium is higher than soil on soil friction because the lean concrete will interlock with the soil or rock. The friction coefficient is higher than 0.7 at the interface between the foundation concrete and the hardened lean concrete with roughened surface. Therefore, the specific interface governing sliding is the soil on soil interface immediately below the lean concrete. The COL applicant is to verify that the friction coefficient at the site is bounded by 0.7 (COL 3.8(13)).

COL 3.8(7) The COL applicant is to confirm that uneven settlement due to construction sequence of the NI basemat falls within the values specified in Table 2.0-1.

COL 3.8(8) The COL applicant is to provide the necessary measures for foundation settlement monitoring considering site-specific conditions.

COL 3.8(9) The COL applicant is to provide testing and inservice inspection program to examine inaccessible areas of the concrete structure for degradation and to monitor groundwater chemistry.

COL 3.8.(10) The COL applicant is to provide the following soil information for the APR1400 site: 1) elastic shear modulus and Poisson's ratio of the subsurface soil layers, 2) consolidation properties including data from one-dimensional consolidation tests (initial void ratio, Cc, Ccr, OCR, and complete e-log p curves) and time-versus-consolidation plots, 3) moisture content, Atterberg limits, grain size analyses, and soil classification, 4) construction sequence and loading history, and 5) excavation and dewatering programs.

COL 3.8(13) The COL applicant is to verify that the friction coefficient at the site is bounded by 0.7.

3.8.7 References

1. 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," U.S. Nuclear Regulatory Commission.

2. ASME Section III, Subsection NE, "Class MC Components," The American Society of Mechanical Engineers, the 2007 Edition with the 2008 Addenda.

3. ASME Section III, Division 2, "Code for Concrete Containments," Subsection CC, American Society of Mechanical Engineers, 2001 Edition with 2003 Addenda.

4. Regulatory Guide 1.35, "Inservice Inspection of Ungrouted Tendons in Prestressed Concrete Containment," Rev. 3, U.S. Nuclear Regulatory Commission, July 1990.

5. Regulatory Guide 1.35.1, "Determining Prestressing Forces for Inspection of Prestressed Concrete Containments," U.S. Nuclear Regulatory Commission, July 1990.

Table 1.8-2 (5 of 29)

Item No.	Description
COL 3.8(7)	The COL applicant is to confirm that uneven settlement due to construction sequence of the NI basemat falls within the values specified in Table 2.0-1.
COL 3.8(8)	The COL applicant is to provide the necessary measures for foundation settlement monitoring considering site-specific conditions.
COL 3.8(9)	The COL applicant is to provide testing and inservice inspection program to examine inaccessible areas of the concrete structure for degradation and to monitor groundwater chemistry.
COL 3.8(10)	The COL application is to provide the following soil information for APR1400 site: 1) Elastic shear modulus and Poisson's ratio of the subsurface soil layers, 2) Consolidation properties including data from one-dimensional consolidation tests (initial void ratio, Cc, Ccr, OCR, and complete e-log p curves) and time-versus-consolidation plots, 3) Moisture content, Atterberg limits, grain size analyses, and soil classification, 4) Construction sequence and loading history, and 5) Excavation and dewatering programs.
COL 3.9(1)	The COL applicant is to provide the inspection results for the APR1400 reactor internals classified as non-prototype Category I in accordance with RG 1.20.
COL 3.9(2)	The COL applicant is to provide a summary of the maximum total stress, deformation, and cumulative usage factor values for each of the component operating conditions for ASME Code Class 1 components except for ASME Code Class 1 nine major components. For those values that differ from the allowable limits by less than 10 percent, the contribution of each loading category (e.g., seismic, deadweight, pressure, and thermal) to the total stress is provided for each maximum stress value identified in this range. The COL applicant is to also provide a summary of the maximum total stress and deformation values for each of the component operating conditions for Class 2 and 3 components required to shut down the reactor or mitigate consequences of a postulated piping failure without offsite power (with identification of those values that differ from the allowable limits by less than 10 percent).
COL 3.9(3)	The COL applicant is to identify the site-specific active pumps.
COL 3.9(4)	The COL applicant is to confirm the type of testing and frequency of site-specific pumps subject to IST in accordance with the ASME Code.
COL 3.9(5)	The COL applicant is to confirm the type of testing and frequency of site-specific valves subject to IST in accordance with the ASME Code.
COL 3.9(6)	The COL applicant is to provide a table listing all safety-related components that use snubbers in their support systems.

COL 3.8(13) The COL applicant is to verify that the friction coefficient at the site is bounded by 0.7.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**255-8285**
SRP Section:	**03.08.05 - Foundations**
Application Section:	**03.08.05**
Date of RAI Issue:	**10/19/2015**

Question No. 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 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.

Response

Please refer to the response to RAI 255-8285, Question 03.08.05-14.

Impact on DCD

DCD Tier 2, Subsections 3.8.5.5.2, 3.8.6, and Table 1.8-2 will be revised, as indicated in the Attachment to RAI 255-8285 Question 03.08.05-14.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**255-8285**
SRP Section:	**03.08.05 – Foundations**
Application Section:	**03.08.05**
Date of RAI Issue:	**10/19/2015**

Question No. 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.

Response

In accordance with SRP 3.8.5 Section II 4, static and dynamic differential settlement was evaluated. For static loading, the dead and live loads are applied in the NI common basemat model. To check differential settlement, the nodes are chosen within a distance of approximately 50ft. DCD Figure 3.8A-18 shows the node locations of the NI common basemat.

For dynamic differential settlement due to seismic loading, TR APR1400-E-S-NR-14006-P, Rev. 1, “Stability Check for NI Common Basemat,” Figures 4-6 through 4-14 show the vertical (Z-direction) displacement at all nodes located in the bottom of the basemat for each site profile, S1 through S9. These figures present the results for the maximum and minimum average value of vertical displacements and instantaneous vertical displacements of each node at the times of the maximum and minimum average vertical displacements. From the figures, the maximum differential settlement is obtained from the difference between the largest displacement and the smallest displacement of the entire basemat (not the differential settlements per 50 ft.). The maximum differential settlement by seismic loading is approximately 0.006 ft. (0.072 in.), which is less than 0.1 inch.

For the detailed evaluation of dynamic differential settlement, all of the displacement data corresponding to all time steps are checked. Table 1 summarizes the maximum displacement, the minimum displacement, and the differential settlement at the time when the differential settlements are maxima for each soil profile. As a result, the maximum differential settlement in Table 1 is approximately 0.0075 ft. (0.09 in.), which is also less than 0.1 inch. The additional detailed evaluation of dynamic differential settlement will be added as indicated in attachment associated with the response.

Table 1. Z(VT) displacement due to Z- input from SASSI

Z(VT) displacement due to Z-input from SASSI						
Site Profies	Max (ft)	Min (ft)	Differen ce (ft)	Distnace (ft)	Differential Settlement per 50ft (ft)	Time (sec)
S1	7.979E-03	5.165E-04	0.0075	251.922	0.0015	7.05
S2	3.490E-04	-6.353E-03	0.0067	218.365	0.0015	6.87
S3	3.614E-04	-3.962E-03	0.0043	250.89	0.0009	6.83
S4	3.240E-03	6.510E-05	0.0032	220.614	0.0007	7.20
S5	1.221E-03	-1.559E-04	0.0014	258.423	0.0003	7.18
S6	1.517E-03	-6.629E-05	0.0016	220.614	0.0004	7.19
S7	1.284E-03	-1.184E-04	0.0014	147.976	0.0005	7.18
S8	7.136E-06	-8.199E-04	0.0008	194.567	0.0002	6.59
S9	3.841E-05	-8.581E-04	0.0009	308.443	0.0001	6.59

Differential settlement between the NI common basemat and the TGB basemat is evaluated with the static loading case (D+L). Technical report, APR1400-E-S-NR-14006-P, Rev. 1, “Stability Check for NI Common Basemat,” Table 4-3 presents the maximum settlement values obtained from evaluating all nodes in the bottom of the NI common basemat and the TGB basemat for soil cases S1, S4, and S8. The differential settlement of the two buildings is conservatively determined from the displacement at the nodes of each basemat which have the maximum settlement instead of nodes adjacent to each other. As shown in Table 4-3 of the TR APR1400-E-S-NR-14006-P, Rev. 1, with regard to each building, the maximum settlement is consistent with the site profiles; i.e., the settlement is the largest in the weakest site and vise versa. The differential settlement between two buildings is not consistent with the site profiles because it depends on a variety of parameters such as the excavation depth, magnitude of applied load, area of applied load (basemat net area) as well as the site profiles. Therefore, it is difficult to conclude that the differential settlement between two buildings is consistent with the site profiles. However, it is noted that the different settlement between the two buildings satisfies the differential settlement criteria.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

Technical report APR1400-E-S-NR-14006-P/NP, Rev.1 will be revised by March 31, 2016.

based on the maximum and minimum displacements of the basemat (not the differential settlements per 50 ft). Added #1

The maximum probable differential settlements of the APR1400 NI common basemat are 0.18 and 0.1 in. for the static (D+L) and seismic (Es) loading conditions, respectively. Therefore, it is concluded that the critical criterion for differential settlement, is 0.5 in. differential settlement per 50 ft.

In addition, the differential settlement between the NI basemat and the other buildings is checked. Additional FE analyses for the turbine generator building (TGB), which is the building adjacent to the NI common basemat are performed for the differential settlement between the NI basemat and other buildings. The superstructure of the TGB consists of braced steel frames, and the basemat of the TGB is located at El. 73 ft 0 in.. The subgrade moduli for the TGB analysis corresponding to S1, S4, and S8 are 28.52 kcf, 121.37 kcf, and 877.20 kcf, respectively (see Table 2-4). The settlement analyses for the TGB basemat are carried out using the GTSTRUDL program. Figure 4-15 shows the FE model for the TGB basemat analysis. The maximum settlements of the NI and TGB basemats are used for calculating the differential settlement. Table 4-3 shows the differential settlement between the NI basemat and the TGB basemat. From the analysis results, it is concluded that the criterion for the differential settlement between the NI basemat and the other buildings, which is 0.5 in., is acceptable.

Added #2

4.1.3 Site Interface for the Nuclear Island Common Basemat

The bearing pressures of the NI common basemat by static and seismic loadings are evaluated in this subsection.

For the bearing pressure, the D+L load (static) case and LC08 through LC15 (dynamic) cases are applied in the basemat and the maximum bearing pressures of the basemat are obtained from the ANSYS static analysis. Table 4-4 shows the bearing pressures by static and dynamic loadings. These bearing pressures are satisfied because the allowable bearing capacity is less than or equal to 15 ksf (static) and 60 ksf (dynamic).

4.2 Stability Check of the Nuclear Island Common Basemat

The NI common basemat structure is evaluated for stability against overturning, sliding, and flotation. The calculated factors of safety against overturning, sliding, and flotation for the applicable load combinations satisfy the criteria shown in Table 4-5.

The normal design groundwater elevation for the APR1400 is 96.67 ft. The extreme groundwater elevation (design basis flood level) is the same as the plant grade level (98.67 ft) for seismic Category I, II, and III structures considering the probable maximum flood level.

In the earthquake load, axial force, shear force, and moment due to horizontal and vertical excitation of the structure are obtained from seismic analysis. Table 4-6 shows the enveloped results of the seismic analysis corresponding to each site profile (S1 through S9). Since the seismic load governs the wind load, a stability check is not considered for the wind load condition. In addition, the earth pressure effect is neglected for a conservative stability check.

4.2.1 Overturning Check

For the overturning check, the possible minimum resisting moment and maximum driving moment are conservatively calculated. In addition, when overturning is checked in combination with seismic forces (E_s), the hydrostatic force at the design water level (H_e) is used. Minimum resisting moment is obtained by multiplying the effective dead load ($D-H_e$) by the minimum distance (d_{min}). Maximum driving moment consists of the overturning moments due to horizontal moments (M_x and M_y), seismic shear forces (F_x and F_y), and upward seismic force (V). The 100-40-40 method is used for upward seismic force.

#1
For the detailed evaluation of dynamic differential settlement, all of the displacement data corresponding to all time steps are checked. Table 4-7 summarizes the maximum displacement, the minimum displacement, and the differential settlement at the time when the differential settlements are maxima for each soil profile. As a result, the maximum differential settlement in Table 1 is approximately 0.0075 ft. (0.09 in.), which is also less than 0.1 inch.

#2
The differential settlement between two buildings is not consistent with the site profiles because it depends on a variety of parameters such as the excavation depth, magnitude of applied load, area of applied load (basemat net area) as well as the site profiles.

Table 4-7

Z(VT) displacement due to Z- input from SASSI

Z(VT) displacement due to Z-input from SASSI						
Site Profies	Max (ft)	Min (ft)	Differen ce (ft)	Distnace (ft)	Differential Settlement per 50ft (ft)	Time (sec)
S1	7.979E-03	5.165E-04	0.0075	251.922	0.0015	7.05
S2	3.490E-04	-6.353E-03	0.0067	218.365	0.0015	6.87
S3	3.614E-04	-3.962E-03	0.0043	250.89	0.0009	6.83
S4	3.240E-03	6.510E-05	0.0032	220.614	0.0007	7.20
S5	1.221E-03	-1.559E-04	0.0014	258.423	0.0003	7.18
S6	1.517E-03	-6.629E-05	0.0016	220.614	0.0004	7.19
S7	1.284E-03	-1.184E-04	0.0014	147.976	0.0005	7.18
S8	7.136E-06	-8.199E-04	0.0008	194.567	0.0002	6.59
S9	3.841E-05	-8.581E-04	0.0009	308.443	0.0001	6.59