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. 03.08.05-9

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 fifty feet 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 fifty 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.

The construction sequence analysis for the NI common basemat is described in section 5.0 of the technical report (APR1400-E-S-NR-14006-P, Rev. 1). From the technical report, the settlements distribution contour for soil profiles S1 and S8 show that soft soil profile (S1) governs the stiff soil profile (S8) due to the concentration of settlement around the NI common basemat. Based on the characteristics of soil profiles S1 through S8, of which the soil layers consist of sand, soft rock or rock, the settlements during construction shall not govern for sand and/or rock site because the total amount of applied loads on the soil profiles S1 through S8 during construction is less than after construction. Therefore, the design of building structures is not affected by the results of the construction sequence, whole design procedure, and results. The variations of soil characteristics not enveloped by the generic soil profiles will be addressed in the COL application phase and account for the site specific parameters.

(2) Short term and long term

Short term settlement is evaluated as a construction sequence analysis limited in the NI common basemat. The considered sequence was based on the concrete pouring sequence of the basemat. The analysis result was summarized in TR Table 5-3. In addition, the differential settlement under the loads (Dead + Live) was checked for the as-built. Therefore, the detailed analysis will be accomplished corresponding to the actual construction sequence using the same methodology described in RAI 255-8285 Question 03.08.05-7.

The generic soil profiles in the APR1400 project consist of sand, soft rock and rock. Considering the characteristics of sand and rock for settlement, the settlement of the APR1400 basemat is calculated by the instantaneous settlement of sand, though time-consolidation effects are not considered. The COL applicant shall consider the time-consolidation effect if cohesive soil is found at the site. The differential settlement of the basemat and bearing stress shall be checked to demonstrate acceptability.

An active settlement monitoring system throughout the entire construction sequence as well as a long-term (plant operation) plan shall be implemented. By monitoring the settlement throughout construction, the COL applicant will be able to modify the construction sequences of adjacent buildings to conform to the site's settlement characteristics and minimize differential settlement. The COL item (COL 3.8(8)) will be changed as shown in the attachment to this response.

(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

For the foundation, the compression-only soil spring to each direction (X, Y, Z) on the basemat nodes was considered. The soil stiffness was calculated using the method described in TR Subsection 2.3. The 3D FE foundation model was considered to achieve the subgrade modulus used in the soil spring. The foundation media model with uniform soil stiffness for each layer throughout the soil is sized enough to capture the shape of deformed soil.

The construction sequence analysis model consists of foundation media (soil layer, SOLID185 elements in the ANSYS program) and the NI common basemat. To capture the Boussinesq effect in soils, the foundation media model is used instead of the soil spring model. The ratio of the width of basemat is (1148 ft) / (353 ft) = 3.25 and the ratio of the width of the foundation media is (1151 ft) / (356 ft) = 3.23 which exceeds the ratio of 3.0. For the depth of foundation, the full depth of the generic soil profile was used to determine the ratio, (1000 ft) / (356 ft) = 2.81.

The foundation media model was developed using the same methodology as specified in technical report (APR1400-E-S-NR-14006-P, Rev. 1) and will be used for the basemat analysis and construction sequence analysis with actual site profiles.

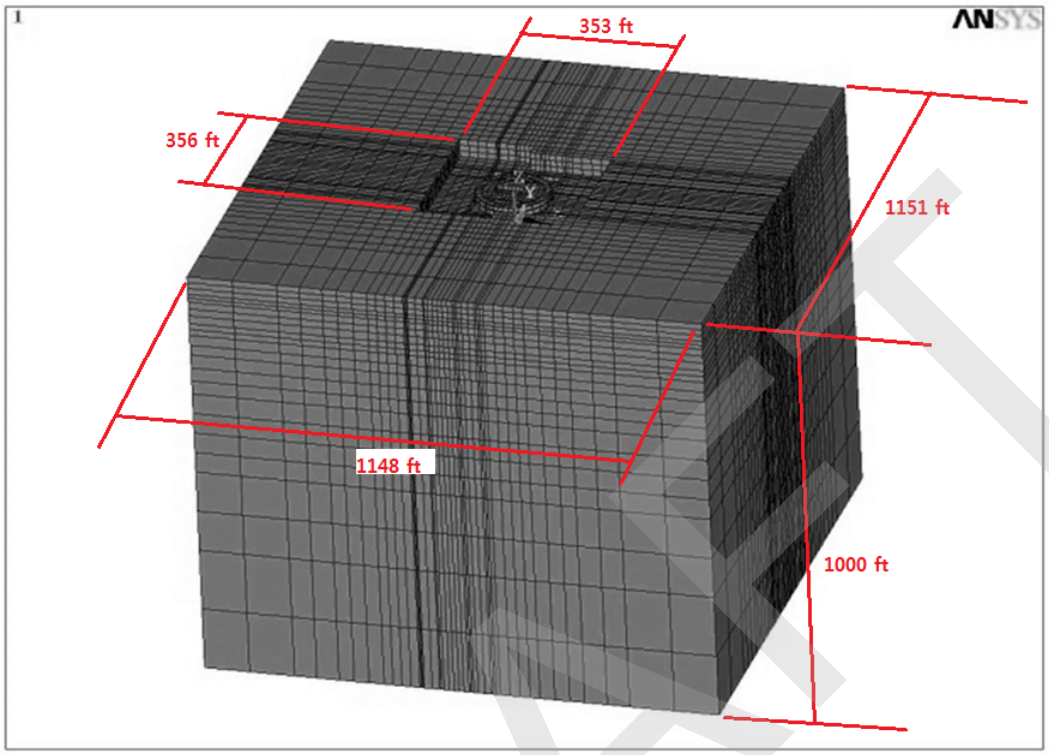

Figure 1. Dimension of Construction Sequence Foundation Media Model

According to SRP Section 3.8.5.II.4.G, an evaluation of stiff and soft spots should be considered in the analysis of the basemat. The stiff and soft spots are not predictable before the site survey or site excavation for the specific site. The variation of soil characteristics such as stiff/soft spot, soil type (granular/cohesive), loss of cement in the mudmat, and uniformity of soil layers effect not only the basemat analysis, but the whole design procedure and results. Therefore, The variations of soil characteristics not enveloped by the generic soil profiles will be addressed in the COL application phase and account for the site specific parameters.

According to the site profile characteristics, the effect of settlement by stiff and soft spots is not governed compared to the effect in the as-built stage because of the characteristics of the sand (generic soil profile). If these soils are found during excavation, the COL applicant shall perform the 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 of the superstructure will be performed and reflected to the design corresponding to the actual construction sequence using the same methodology described in DCD Tier 2, Section 3.8.5.4 (refer to the response 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, then loss of subgrade contact is considered corresponding to the actual site status (DCD COL item, COL

3.8(12)).

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

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