APR1400
Feedback on Response to RAI 255-8285, Question 03.08.05-7
Prepared September 2, 2016

The items identified below should be addressed. The feedback provided is based on (1) NRC SRP 3.8.5II.4 criteria, (2) NRC Technical Rationale for Enhancements to Seismic and Structural Review Guidance, Rev. 1 (on ADAMS), (3) ASME PVP2011-57600 paper "Structural Design Challenges in Design Certification for New Reactors, and (4) EM 1110-1-1904, Engineering and Design Settlement Analysis, US Army Corps of Engineers, 9/30/94.

1. The information on page 3/8 of the response states: "In order to determine whether the soft soil case is the governing case for the construction sequence analysis, the moment diagram for each section of the soil profiles (S1, S8) is compared under the abnormal/extreme environment load combination (LC08)." The staff notes that no conclusion is made in the response whether the soft condition governs, in which case only the soft soil condition will be evaluated for construction sequence or not. From the three figures, there are some regions where the stiffer soil condition (S8) seems to govern in terms of the bending moment across the foundation. Thus, explain if both cases of S1 and S8 (or even S9 which is stiffer) will be analyzed and the design will be based on the envelop/governing loads from these cases.

2. The text on page 7/8 and markup for COL 3.8(11) (page 3/3 of the attachment), are not clear regarding several items. Therefore, respond to the items listed below.

a) Confirm whether the following italicized (and highlighted) markups inserted by the staff clarify the meaning of the quoted COL 3.8(11) markup, and revise the COL item as appropriate.

"~~The~~ *A* detailed *site-specific* construction sequence analysis for the basemat and superstructure shall be performed according to the construction plan *developed by the COL applicant*. The construction *sequence analysis* shall use foundation media model, material properties, and superstructure model that ~~was~~*were* used for DC application. *Also,*~~And~~ the differential settlement of the basemat and concrete stress in the structure shall be checked to demonstrate acceptability. If the results exceed limits of Table 2.0-1, a detailed evaluation and revised construction plan will be described by the *COL*~~Combined License~~ applicant."

b) The above COL Item only refers to construction sequence and corresponding differential settlement analysis. Per SRP 3.8.5II.4 and some of the other references cited above, the site

specific analysis should also consider post-construction settlement analysis (i.e., also includes normal operation through the life of the plant) if additional settlements may occur based on the site-specific soil conditions such as consolidation effects over time, heave, and/or contain clay soils.

c. The above COL item indicates that differential settlement of the basemat and the concrete stress in the structure shall be checked. If the differential settlement meets the acceptance criteria, explain the purpose of also checking the concrete stresses. If concrete stresses do need to be checked, then additional guidance is needed to explain whether this should be performed for all load combinations including the construction sequence, or why not.

d) The above COL item indicates that if the results exceed the limits of DCD Table 2.0-1, a detailed evaluation and revised construction plan will be described by the COL applicant. Currently, Table 2.0-1 does not provide acceptance criteria for stresses. Also, Table 2.0-1 and DCD Tier 1, do not provide acceptance criteria for all aspects of settlement. DCD Table 2.0-1 and DCD Tier 1 should include acceptance criteria for the maximum vertical settlement, tilt settlement, differential settlement between adjacent structures, and angular distortion (angular distortion is only needed for Table 2.0-1), unless otherwise justified. Details about each of these are discussed in Item e immediately below.

e) Based on the references cited at the top of this feedback, there are four types of settlements that are important to consider in the DC and COL stages. The staff would find the approach for developing the acceptance criteria acceptable if the four types of settlements are addressed as given below for each seismic Category I structure.

(1) <u>Maximum vertical settlement</u>
Maximum vertical building settlement for each structure is the maximum calculated vertical deformation for the construction and post construction phases. The term settlement means the displacements that occur only from the gravity loads of the structure and should be calculated from the construction sequence and post construction sequence analysis only (i.e., not all load combinations). If a higher limit of acceptance criterion is desired (i.e., higher than the calculated value), then the design of the structures, systems and components should be shown to be acceptable for this higher limit.

(2) Maximum tilt settlement

Maximum tilt settlement is the calculated rotational deformation of the structure for construction and post construction phases. This corresponds to the calculated slope of the settlement for each structure, and can be identified as the ratio of the differential vertical displacement at the opposite edges of the building to the length between the two edges (e.g., 0.5 inches per 50 ft). The tilt values for each structure in each direction or the governing value (i.e., smaller value for each direction of the given structure) should be determined. See Item (1) above for further guidance.

(3) Maximum differential settlement between structures

The maximum differential building settlement is the difference in the vertical calculated deformation between adjacent structures for the construction and post construction phases. See Item (1) above for further guidance.

(4) Angular distortion

Angular distortion relates to the curvature of the basemat due to settlement of the structure for construction and post construction phases. Curvature is important because the basemat reinforcement in different regions is designed for moments that are related to the curvature of the slab, not to the maximum vertical displacement of the structure or to the tilt settlement (both of which are more like rigid body motions).

Angular distortion of the basemat is calculated as the differential vertical displacement between two adjacent points in different regions throughout the basemat. It is normally obtained from the settlement profile distribution calculated from the FEM of the structure used for design (e.g., ANSYS FEM in the case of the NI) that was used to design the basemat. It should not be taken from the SASSI analysis, because (a) the basemat reinforcement was designed based on the ANSYS FEM of the NI, not from the SASSI basemat settlement profile and (b) angular distortion applies to the construction and post construction stages for gravity loads, not seismic.

Since the angular distortion values are different for different regions (e.g., between walls at various regions of the basemat), it is inappropriate to take the maximum value of all of the angular distortions throughout the entire basemat because each region of the basemat was designed for the resulting angular distortion in that region, not the maximum angular distortion throughout the basemat. If the maximum value throughout the basemat was used as the acceptance criterion, it would be unconservative. An acceptable way to consider the angular distortion in the DC stage for different regions is to calculate the settlement contours from the ANSYS FEM basemat, which can easily be

plotted from the ANSYS results which can then be used as the acceptance criteria for the COL applicant. The settlement contours should be developed for each of the steps of the constructions sequence and post construction. In some cases, if there are too many steps to consider (e.g., for the basemat), then it may be possible to skip some of the intermediate steps, with appropriate explanation. The above approach should also be performed for the EDGB and DFOT structures as well, but because they are very simple and small structures, there is no need to consider the various steps in the construction sequence.

The approach for developing the acceptance criteria described above, for the maximum vertical settlement, tilt settlement, differential settlement between structures, and angular distortion should be described in DCD Section 3.8, identified in the appropriate section in Chapter 2, and identified in DCD Tier 1 (without angular distortion). In addition, the KHNP technical report on stability evaluation that includes settlement evaluations should be revised accordingly.

f) Besides settlement as discussed above, the maximum vertical and horizontal displacement of the structure for all/governing load combinations including dead load, live load, and seismic should be determined. This is important to ensure that there is no interaction/contact between seismic Category I structures and any other structure, system, and components (SSC). KHNP is requested to confirm this was performed for above ground and below ground locations which could affect safety related SSCs, including for example, tunnel, conduit, piping, etc., unless there is a sufficient expansion joint or flexibility designed in the interface to accommodate these displacements. KHNP should confirm this was done and identify where in the DCD this is described. If some of the SSCs have not been designed as yet, the need to perform this should at least be identified in the DCD.

3. The text on page 7/8 and markup for COL 3.8(12) (page 3/3 of the attachment) appear to apply if there are site-specific conditions found at the site (e.g., stiff/soft spots, different soil types, potential for loss of cement in the mudmat, nonuniformtiy of the soil layers), that were not designed for in the DC stage. In these cases, Item 2) in the text on page 7/8 and markup for COL 3.8(12) indicates that “a site-specific evaluation will be performed.” This should be clarified in greater detail to ensure that this includes evaluation of the basemat and structure design (forces/stresses), settlement evaluations (as discussed in Item 2 above, soil bearing calculation versus demand, and stability evaluation, for all/governing load combinations, unless otherwise justified.