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.:	**9-7848**
SRP Section:	**02.05.02 – Vibratory Ground Motion**
Application Section:	**2.5.2**
Date of RAI Issued:	**05/14/2015**

Question No. 02.05.02-2

Section 2.5.2.6 of the APR1400 DCD describes the conditions required for a site to be considered suitable for a COL application. Specifically, the DCD states, “The COL applicant is to confirm that the site meets the following requirements,” followed by a list of four requirements (a-d) and a provision for performing additional analyses if some of these requirements are not met (e).

In accordance with Appendix S to 10 CFR Part 50, regarding APR1400 DCD Section 2.5.2.6, please discuss the following and propose associated APR1400 DCD modification to text and tables:

I. As currently written in the DCD, the COL applicant should confirm that its site meets requirements (a), (b), (c), and (d), all four requirements at once. Is it necessary for the COL applicant to meet all of the requirements in (a-d)?

II. As currently written in the DCD, (e) states what a COL applicant should do if requirements (a), (b), and (c) are not satisfied, but it does not explicitly mention (d). What, if any, provision for additional analysis in (e) applies to the requirement in (d) that the site specific GMRS is enveloped by the hard rock high frequency (HRHF) spectrum for sites that have a supporting medium with a shear-wave velocity of greater than 4,900 ft/s overlying hard rock?

Response

I. It is not necessary for the COL applicant to meet all of the requirements in (a-d).

Since APR1400 standard design for seismic Category I structures, systems and components (SSCs) has been designed with the CSDRS-compatible seismic ground motion input for

generic site conditions of S1 through S9 and a fixed-base (S10) site conditions, it is necessary to meet the requirement in (a) for all sites to be considered for COL applications.

For sites, S1 through S9 described in Table 3.7A-1 through 3.7A-9, in addition to the requirement in (a), it is also necessary to meet the requirement in (c).

For hard rock sites, S8 through S10, the requirements in (d) need be satisfied. In addition, a fixed-base site (S10) with a low-strain shear wave velocity of the supporting medium for the Nuclear Island greater than 2,804 m/sec (9,200 ft/s), should satisfy the requirements in (b).

If the requirements above are not satisfied, a site-specific seismic analysis is performed to generate in-structure response spectra at key locations using the procedure described in Appendix 3.7A and 3.7B. The site-specific in-structure response spectra generated are compared with the corresponding in-structure response spectra provided in Appendix 3.7A (COL 2.5(5)). In addition, for a hard rock site, if the site-specific GMRS determined at the finished grade are not enveloped by the HRHF response spectra shown in Figures 3.7.12 and 3.7.13 (COL 2.5(4)), site-specific seismic response analyses are performed using the procedure described in Appendix 3.7B and in the EPRI White Paper, “Seismic Screening of Components Sensitive to High Frequency Vibratory Motions” (COL 2.5(6)).

II. The last sentence of DCD section 2.5.2.6 (page 2.5-4) will be revised as follows:

In addition, if the requirement d is not satisfied, site-specific seismic response analyses are performed using the procedure described in Appendix 3.7B and in the EPRI White Paper, “Seismic Screening of Components Sensitive to High Frequency Vibratory Motions” (Reference 6) (COL 2.5(6)).

Impact on DCD

DCD Subsection 2.5.2.6 will be revised as indicated on 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 and Environmental Reports.

if the requirement d is not satisfied,

response spectra generated are compared with the corresponding in-structure response spectra provided in Appendix 3.7A (COL 2.5(5)). In addition, ~~if the site-specific GMRS determined at the finished grade are not enveloped by the HRHF response spectra,~~ site-specific seismic response analyses are performed using the procedure described in Appendix 3.7B and in the EPRI White Paper, "Seismic Screening of Components Sensitive to High Frequency Vibratory Motions" (Reference 6) (COL 2.5(6)).

2.5.2.7 Soil Uniformity

The APR1400 is designed for application at a site where the foundation conditions do not have extreme variation within the standard plant structure footprint. The subsurface may consist of layers that dip with respect to the horizontal. If the dip is less than 20 degrees, the generic analysis using horizontal layers is applicable as described in NUREG/CR-0693 (Reference 7). The physical properties of the foundation medium may or may not vary systematically across a horizontal plane. The methodology for checking uniformity is to calculate from the boring logs a series of "best-estimate" planes beneath the standard plant structure footprint that define the top and bottom of each soil or rock layer. These planes should represent and delineate stratigraphic boundaries, lithologic changes, and unconformities, but most important, they should represent boundaries between layers having different shear wave velocities. Shear wave velocity is the primary property used for defining uniformity of a site.

The distribution of bearing reactions under the basemat is a function of the subgrade modulus, which in turn is a function of the shear wave velocity and soil profile. Site-specific data should be provided to evaluate the variation of subgrade modulus or shear wave velocity across the footprint and to demonstrate the site is within the range considered for design of the standard plant structure basemat. The deeper that the non-uniform layer is located below the foundation, the less influence it has on the bearing pressures at the basemat.

The COL applicant is to perform an evaluation of the subsurface conditions within the standard plant structure footprint based on the geologic investigation in accordance with NRC RG 1.132 (COL 2.5(7)). Subsurface conditions may be considered uniform if the geologic and stratigraphic features can be correlated from one boring or sounding location to the next with relatively smooth variations in thicknesses or properties of the geologic units. An occasional anomaly or a limited number of unexpected lateral variations may

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Question No. 02.05.02-3

Section 2.5.2.6 states: “For soil sites, the lower bound of the site-specific strain-compatible soil profile is greater than the lower bound of the generic strain-compatible soil profiles used in the APR1400 seismic analyses shown in Tables 3.7A-1 through 3.7A-9 and Figures 3.7A-3 through 3.7A-11 (COL 2.5(3)).

The “lower bound” comparison requirement is not enough to determine if a COL site is consistent with the APR1400 generic soil profiles. For example, each APR1400 generic soil profile has shear wave velocities that generally increase with depth, which a COL site would need to demonstrate to determine that its site is consistent with the generic soil profiles considered in the APR1400 DC. In addition to shear wave velocities, a COL applicant would also need to consider the soil shear modulus (G) and hysteretic damping considered in the APR1400 DC.

In accordance with Appendix S to 10 CFR Part 50, regarding APR1400 DCD Section 2.5.2.6, please propose modifications to the APR1400 DCD text and tables, where applicable, to provide more comprehensive comparison requirements for a COL applicant to use when determining if the COL site soil profile is consistent with the APR1400 generic soil profiles. In addition to DCD modification in Section 2.5.2.6, if applicable, propose changes in Section 2.5.4 and 2.5.5 where necessary.

Response

For more comprehensive comparison requirements of a COL applicant, the requirement (c) in the DCD Subsection 2.5.2.6 will be revised as follows:

For soil sites, (i) the requirement for the site-specific weight densities of subsurface soils is to be no less than 2002.3 kg/m^3 (125 lb/ft^3) and the site-specific strain-compatible soil hysteresis

damping ratio profile is to be less than that shown in Table 3.7A-1, (ii) the site-specific soil properties (weight density, strain-compatible soil shear and compression wave velocity, and strain-compatible soil hysteresis damping ratio) have their profiles generally increasing with depth from the ground surface in a manner similar to the general profile shapes shown in Tables 3.7A-1 through 3.7A-9 and Figures 3.7A-3 through 3.7A-11, (iii) the site-specific soil profiles have no inverse condition, i.e., the soil properties of a deeper soil layer are less than the properties of the soil layer above it, and (iv) the site-specific soil profiles are bounded by the soil profiles of the generic site conditions S1 through S9 considered for the standard design as shown in Tables 3.7A-1 through 3.7A-9 and Figures 3.7A-3 through 3.7A-11 (COL 2.5(3)).

Impact on DCD

DCD Subsections 2.5.2.6, 2.5.6 and the associated COL Table 1.8-2 will be revised as indicated on 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 and Environmental Reports.

than 304.8 m/s (1,000 ft/s), the submaterials are completely excavated to expose competent material with a low-strain shear wave velocity equal to or greater than 304.8 m/s (1,000 ft/s), and the GMRS are defined as a free-field motion on the hypothetical outcrop after the excavation. For a site where the nuclear island is located on hard rock with a shear wave velocity greater than 2,804 m/s (9,200 ft/s), the site-specific GMRS can be defined at the foundation level. For this case, GMRS could be referred to as foundation

(i) the requirement for the site-specific weight densities of subsurface soils is to be no less than 2002.3 kg/m^3 (125 lb/ft^3) and the site-specific strain-compatible soil hysteresis damping ratio profile is to be less than shown in Table 3.7A-1, (ii) the site-specific soil properties (weight density, strain-compatible soil shear and compression wave velocity, and strain-compatible soil hysteresis damping ratio) have their profiles generally increasing with depth from the ground surface in a manner similar to the general profile shapes shown in Tables 3.7A-1 through 3.7A-9 and Figures 3.7A-3 through 3.7A-11, (iii) the site-specific soil profiles have no inverse condition, i.e., the soil properties of a deeper soil layer are less than the properties of the soil layer above it, and (iv) the site-specific soil profiles are bounded by the soil profiles of the generic site conditions S1 through S9 considered for the standard design as shown in Tables 3.7A-1 through 3.7A-9 and Figures 3.7A-3 through 3.7A-11

response motions at the bottom elevation of the nuclear island shown in Figures 3.7A-12 through 3.7A-14 (COL 2.5(2)).

b. For hard rock sites with a low-strain shear wave velocity of supporting medium for the nuclear island greater than 2,804 m/sec (9,200 ft/s), FIRS of the nuclear island are completely enveloped by the CSDRS (COL 2.5(2)).

c. For soil sites, ~~the lower bound of the site-specific strain-compatible soil profile is greater than the lower bound of the generic strain-compatible soil profiles used in the APR1400 seismic analyses shown in Tables 3.7A-1 through 3.7A-9 and Figures 3.7A-3 through 3.7A-11~~ (COL 2.5(3)).

d. For a site with a low-strain shear wave velocity of supporting medium for the nuclear island higher than 1,494 m/s (4,900 ft/s) overlaying a hard rock with a low-strain shear wave velocity greater than 2,804 m/s (9,200 ft/s), the site-specific GMRS determined at the finished grade are completely enveloped by the APR1400 HRHF response spectra shown in Figures 3.7-12 and 3.7-13 (COL 2.5(4)).

e. If the requirements a, b, and c listed above are not satisfied, a site-specific seismic analysis is performed to generate in-structure response spectra at key locations using the procedure described in Appendix 3.7A. The site-specific in-structure

2.5.4.12 Techniques to Improve Subsurface Conditions

If necessary to improve subsurface conditions, the plans, summaries of specifications, and methods of quality control are described in the site-specific information.

2.5.5 Stability of Slopes

No assumptions in regard to slope stability are used in the evaluation of the APR1400 standard design.

The stability of all natural and manmade slopes, including embankments and dams, that are vital to the safety of APR1400, is included in site-specific information.

2.5.6 C

(i) the requirement for the site-specific weight densities of subsurface soils is to be no less than 2002.3 kg/m^3 (125 lb/ft^3) and the site-specific strain-compatible soil hysteresis damping ratio profile is to be less than shown in Table 3.7A-1, (ii) the site-specific soil properties (weight density, strain-compatible soil shear and compression wave velocity, and strain-compatible soil hysteresis damping ratio) have their profiles generally increasing with depth from the ground surface in a manner similar to the general profile shapes shown in Tables 3.7A-1 through 3.7A-9 and Figures 3.7A-3 through 3.7A-11, (iii) the site-specific soil profiles have no inverse condition, i.e., the soil properties of a deeper soil layer are less than the properties of the soil layer above it, and (iv) the site-specific soil profiles are bounded by the soil profiles of the generic site conditions S1 through S9 considered for the standard design as shown in Tables 3.7A-1 through 3.7A-9 and Figures 3.7A-3 through 3.7A-11.

COL 2.5(1)

COL 2.5(2)

finished grade in the free field. Alternately, the COL applicant is to confirm that the FIRS of the nuclear island are completely enveloped by the CSDRS for a hard rock site with a low-strain shear wave velocity of supporting medium for the nuclear island greater than 2,804 m/s (9,200 ft/s).

COL 2.5(3) The COL applicant is to confirm that ~~the lower bound of the site-specific strain-compatible soil profile for a soil site is greater than the lower bound of the generic strain-compatible soil profiles used in the APR1400 seismic analyses~~.

COL 2.5(4) The COL applicant is to confirm that the site-specific GMRS determined at the finished grade are completely enveloped by the HRHF response spectra for a site with a low-strain shear wave velocity of supporting medium for the nuclear island higher than 1,494 m/s (4,900 ft/s) overlaying hard rock with a low-strain shear wave velocity greater than 2,804 m/s (9,200 ft/s).

Table 1.8-2 (2 of 29)

Item No.	Description
COL 2.5(1)	The COL applicant is to provide the site-specific information on geology, seismology, and geotechnical engineering as required in NRC RG 1.206.
COL 2.5(2)	The COL applicant is to confirm that the foundation input response spectra (FIRS) of the nuclear island are completely enveloped by the CSDRS-compatible free-field response motions at the bottom elevation of the nuclear island for a site with the low-strain shear wave velocity greater than 304.8 m/s (1,000 ft/s) at the finished grade in the free field. Alternately, the COL applicant is to confirm that FIRS of the nuclear island are completely enveloped by the CSDRS for a hard rock site with a low-strain shear wave velocity of supporting medium for the nuclear island greater than 2,804 m/s (9,200 ft/s).
COL 2.5(3)	The COL applicant is to confirm that ~~the lower bound of the site-specific strain-compatible soil profile for a soil site is greater than the lower bound of the generic strain-compatible soil profiles used in the APR1400 seismic analyses.~~
COL 2.5(4)	The COL applicant is to confirm that the site-specific GMRS determined at the finished grade are completely enveloped by the hard rock high frequency (HRHF) response spectra for a site with a low-strain shear wave velocity of supporting medium for the nuclear island higher than 1,494 m/s (4,900 ft/s) overlaying a hard rock with a low-strain shear wave velocity greater than 2,804 m/s (9,200 ft/s).
COL 2.5(5)	The COL applicant is to perform a site-specific seismic analysis to generate in-structure response spectra at key locations using the procedure described in Appendix 3.7A if COL
COL 2.5(6)	
COL 2.5(7)	
COL 2.5(8)	
COL 3.2(1)	The COL applicant is to identify the seismic classification of site-specific SSCs that should be designed to withstand the effects of the SSE.
COL 3.2(2)	The COL applicant is to identify the quality group classification of site-specific systems and components and their applicable codes and standards.
COL 3.3(1)	The COL applicant is to demonstrate that the site-specific design wind speed is bounded by the design wind speed of 64.8 m/s (145 mph).
COL 3.3(2)	The COL applicant is to demonstrate that the site-specific seismic Category II structures adjacent to the seismic Category I structures are designed to meet the provisions described in Subsection 3.3.1.2.
COL 3.3(3)	The COL applicant is to provide reasonable assurance that site-specific structures and components not designed for the extreme wind loads do not impact either the function or integrity of adjacent seismic Category I SSCs.

(i) the requirement for the site-specific weight densities of subsurface soils is to be no less than 2002.3 kg/m^3 (125 lb/ft^3) and the site-specific strain-compatible soil hysteresis damping ratio profile is to be less than shown in Table 3.7A-1, (ii) the site-specific soil properties (weight density, strain-compatible soil shear and compression wave velocity, and strain-compatible soil hysteresis damping ratio) have their profiles generally increasing with depth from the ground surface in a manner similar to the general profile shapes shown in Tables 3.7A-1 through 3.7A-9 and Figures 3.7A-3 through 3.7A-11, (iii) the site-specific soil profiles have no inverse condition, i.e., the soil properties of a deeper soil layer are less than the properties of the soil layer above it, and (iv) the site-specific soil profiles are bounded by the soil profiles of the generic site conditions S1 through S9 considered for the standard design as shown in Tables 3.7A-1 through 3.7A-9 and Figures 3.7A-3 through 3.7A-11.