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.:	**8-7847**
SRP Section:	**02.05.04 – Stability of Subsurface Materials and Foundations**
Application Section:	**2.5.4**
Date of RAI Issued:	**05/14/2015**

Question No. 02.05.04-3

APR 1400 DCD Table 2.0-1 provides the minimum soil angle of internal friction. In accordance with 10 CFR Parts 50, 52.47 and 100, please provide the basis for the selection of this parameter and clarify the applicability of it (i.e. is it for soil below the footprint of the nuclear island at its excavation depth, is it a backfill requirement or both). Please propose changes and/or updates to section 2.5.4.2 and Table 2.0-1.

Response

The shear wave velocity of soil in the generic soil profiles for the APR1400 is a minimum of 1,000 ft/sec. According to the Uniform Building Code (Reference 1), the soil for a shear wave velocity of 600~1,200 ft/sec is considered as stiff soil which is medium dense to dense soil. Roy E. Hunt (Reference 2) suggests that the medium dense to dense soil has the internal friction angel of 32~40 degrees. Considering the above, the minimum internal friction angle of soil with a shear wave velocity of 1,000 ft/sec has been selected as 35 degrees. The minimum soil angle of internal friction is applied below the footprint of the Seismic Category I structures at its excavation depth. The friction angle of soil is used for estimating the friction resistance of the foundation. The friction coefficient derived from a friction angle of 35 degrees was used for checking basemat sliding. As a result, the calculated Factor of Safety (FOS) is 1.51 which is greater than the required FOS of 1.10. There are no recommended changes to Section 2.5.4.2 or Table 2.0-1 based on this response.

References

1) Uniform Building Code (1997), Section 1636, Site Categorization.
2) Roy E. Hunt (1984), 'Geotechnical Engineering Investigation Manual', Table 3.28 Common Properties of Cohesionless Soils, Mcgraw Hill.

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 and Environmental Reports.

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.:	**8-7847**
SRP Section:	**02.05.04 – Stability of Subsurface Materials and Foundations**
Application Section:	**2.5.4**
Date of RAI Issued:	**05/14/2015**

Question No. 02.05.04-4

APR 1400 DCD Table 2.0-1 provides the minimum dynamic properties requirements for Structural Fill Granular (SFG). These properties are: backfill density, Poisson's ratio, minimum dynamic shear modulus, minimum damping ratio and strain-compatible minimum shear wave velocity. In accordance with 10 CFR Parts 50, 52.47 and 100, please provide the basis for the selection of these SFG parameters and clarify, for each parameter, its applicability (i.e. is it applicable to backfill on the sides of Seismic Category I structures, underneath Seismic Category I structures and/or in between Seismic Category I structures). Please propose changes and/or updates to section 2.5.4.5 and Table 2.0-1.

Response

The basis for the selection of SFG parameters are as follows.

a. Backfill density: SFG is well graded dense gravelly soil. Roy E. Hunt (Reference 1) suggested the representative value of density of well graded dense gravelly soil as 137pcf (2.21g/cm^3) and this value has been selected as design density value.

b. Poisson's Ratio: It is known that the dynamic Poisson's ratio of soil ranges from 0.3 to 0.35 (Prakash & Puri, Reference 2). Considering the above, the average value 0.33 has been selected as the representative value of dynamic Poisson's ratio of backfill material.

c. Dynamic Shear Modulus: Seed & Idriss (Soil Moduli and Damping Factors for Dynamic Response Analysis, 1970, Reference 3) suggested a relationship between the dynamic shear modulus and the confining pressure as $G=1000*K_2*(\sigma_m)^{1/2}$ at low strains of the order of 10^{-4} % in psf unit ($G=22.1*K_2*(\sigma_m)^{1/2}$ in kg/cm^2 unit), where σ_m is the average effective confining pressure of soil and K_2 is the coefficient which ranges from 80 to 180 for gravelly soil. For a representative value for K_2 of 90 that has been selected; the dynamic shear modulus G becomes $G=2000*(\sigma_m)^{1/2}$ in kg/cm^2 unit.

d. Damping Ratio: Seed & Idriss (Moduli and Damping Factors for Dynamic Analyses of Cohesionless Soils, 1976, Reference 4) suggests the damping ratios and the strain ranges for gravelly soils. The average damping ratio of gravelly soil from Seed & Idriss has been applied for the APR1400 design.

e. Strain-compatible minimum shear wave velocity: The strain-compatible minimum shear-wave velocity (510 fps) for the backfill is obtained from the computed low-strain shear-wave-velocity and the backfill shear-modulus-degradation curve (G/Gmax) in Table 2.0-1, using the averaged horizontal shear strains in generic site profiles S1 through S9. (Tables A-19 through A-27 of Technical Report APR1400-E-S-NR-14003-P, Rev. 0.)

Each parameter specified above is applicable to backfill on the sides of Seismic Category I structures and between Seismic Category I structures. There are no recommended changes to Sections 2.5.4.2, 2.5.4.5 or Table 2.0-1 based on this response.

References

1) Roy E. Hunt (1984), 'Geotechnical Engineering Investigation Manual', Table 3.28 Common Properties of Cohesionless Soils, Mcgraw Hill.

2) Shamsher Prakash and Vijay K. Puri (1988), 'Foundations for Machines : Analysis and Design', Table 3.1 Velocity of Shear and Compression Waves through Different Materials, John Wiley and Sons.

3) H. Bolton Seed and I. M. Idriss (1970), 'Soil Moduli and Damping Factors for Dynamic Response Analyses', Report No. EERC 70-10, University of California, Berkeley, Calif.

4) H. Bolton Seed and I. M. Idriss (1976), 'Moduli and Damping Factors for Dynamic Analyses of Cohesionless Soils', ASCE, Journal of Geotechnical Engineering, Vol.112, No.11, pp.1016-1032,

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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 and Environmental Reports.

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.:	**8-7847**
SRP Section:	**02.05.04 - Stability of Subsurface Materials and Foundations**
Application Section:	**2.5.4**
Date of RAI Issued:	**05/14/2015**

Question No. 02.05.04-5

In meeting the requirements of 10 CFR Part 52.47, the applicant is to provide the site parameters postulated for the design. APR1400 DCD report APR1400-E-S-NR-14003-P indicates that under the Nuclear Island common basemat, a layer of lean concrete approximately 3 ft thick will be backfilled between the bottom of the basemat and the base of the soil/rock excavation pit. In accordance with 10 CFR Parts 50, 52.47 and 100, please provide or cross reference details on the properties of the lean concrete backfill in section 2.5.4.5; and propose changes or updates to Table 2.0-1.

Response

Under the Nuclear Island common basemat of the APR1400 standard plant, a layer of approximately 0.91m (3 ft) thick lean concrete with a minimum compressive strength of 140 kg/cm^2 (2,000 psi) is backfilled between the bottom of the basemat and the base of the soil/rock excavation pit. The description of the lean concrete backfill under the Nuclear Island common basemat will be incorporated in DCD Section 2.5.4.5. In addition, the COL Item 2.5(8) in DCD Section 2.5.6 will be revised in accordance with Section 2.5.4.5 wording. Since the lean concrete is not backfilled for all seismic Category I structures and the properties of lean concrete are not a site parameter, updates to Table 2.0-1 are not necessary.

Impact on DCD

DCD Subsections 2.5.4.5, 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.

2.5.4.4 Geophysical Surveys

A description is provided of the geophysical investigations performed at the site to determine the dynamic characteristics of the soil or rock, including geophysical methods used to determine foundation conditions. The results of compressional and shear wave velocity surveys and electric resistivity surveys performed to evaluate the occurrence and characteristics of the foundation soils and rocks are provided in tables and profiles.

and compressive strength of lean concrete under the nuclear island basemat

2.5.4.5 Excavations and Backfill

Site-specific information is provided for excavation and backfill, including properties of borrow and backfill materials, extent (horizontally and vertically) of all seismic Category I excavations, compaction specifications, dewatering, excavation methods, and control measures of groundwater during excavation. Minimum requirements of structural fill granular (SFG) for dynamic properties are described in Table 2.0-1. The typical APR1400 site arrangement is shown in Figure 1.2-1 and the typical profile of basemat and SFG is shown in Figure 2.5-1.

The COL applicant is to confirm that the dynamic properties of SFG to be used in construction of the APR1400 seismic Category I structures satisfy the SFG requirements provided in Table 2.0-1 (COL 2.5(8)).

and minimum compressive strength of 140 kg/cm² (2,000 psi) for lean concrete

2.5.4.6 Groundwater Conditions

Basic groundwater conditions are described in Section 2.4. In this subsection, the

Under the nuclear island common basemat, a layer of approximately 0.91m (3 ft) thick lean concrete with a minimum compressive strength of 140 kg/cm² (2,000 psi) is backfilled between the bottom of the basemat and the base of the excavation pit.

2.5.4.7 Response of Soil and Rock to Dynamic Loading

Site-specific information is provided on the response of soil and rock to dynamic loading, including investigations to determine the effects of prior earthquakes on the soils and rocks, compressional and shear wave velocity profiles determined from field seismic surveys, and the results of dynamic tests in the laboratory on samples of the soil and rock. The methodology of site response analysis is described in Appendix 3.7A.

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 2.5(2) and COL 2.5(3) above are not met. In addition, the COL applicant is to confirm that the site-specific in-structure response spectra so generated are enveloped by the corresponding in-structure response spectra provided in Appendix 3.7A.

and compressive strength of lean concrete under the nuclear island basemat

COL 2.5(6) The COL applicant is to perform a site-specific seismic response analysis using the procedure described in Appendix 3.7B and the EPRI White Paper "Seismic Screening of Components Sensitive to High Frequency Vibratory Motions" (Reference 6), if COL 2.5(4) is not met.

COL 2.5(7) 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(8) The COL applicant is to confirm that the dynamic properties of SFG to be used in construction of the APR1400 seismic Category I structures satisfy the SFG requirements provided in Table 2.0-1.

and minimum compressive strength of 140 kg/cm^2 (2,000 psi)

2.5.7 References

1. Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, June 2007.

2. Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants," Rev. 2, U.S. Nuclear Regulatory Commission, October 2003.

3. Regulatory Guide 1.138, "Laboratory Investigations of Soils and Rocks for Engineering Analysis and Design of Nuclear Power Plants," Rev. 2, U.S. Nuclear Regulatory Commission, December 2003.

4. Regulatory Guide 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion," U.S. Nuclear Regulatory Commission, March 2007.

5. NRC DC/COL-ISG-017, "Interim Staff Guidance on Ensuring Hazard-Consistent Seismic Input for Site Response and Soil Structure Interaction Analyses," U.S. Nuclear Regulatory Commission, August 2009.

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 2.5(2) and COL 2.5(3) above are not met. In addition, the COL applicant is to confirm that the site-specific in-structure response spectra so generated are enveloped by the corresponding in-structure response spectra provided in Appendix 3.7A.
COL 2.5(6)	The COL applicant is to perform a site-specific seismic response analysis using the procedure described in Appendix 3.7B and the EPRI White Paper, "Seismic Screening of Compo[illegible]" if COL 2.5(4) is not met.
COL 2.5(7)	The C[illegible]e conditions within the standa[illegible]ation in accordance with NRC R[illegible]
COL 2.5(8)	The COL applicant is to confirm that the dynamic properties of structural fill granular to be used in construction of the APR1400 seismic Category I structures satisfy the requirements of structural fill granular provided in Table 2.0-1. and compressive strength of lean concrete under the nuclear island basemat and minimum compressive strength of 140 kg/cm^2 (2,000 psi)
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 clas[illegible] components and their applicable codes and standards.
COL 3.3(1)	The COL applicant is to demonstrate that the site-spec[illegible] 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.

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.:	**8-7847**
SRP Section:	**02.05.04 - Stability of Subsurface Materials and Foundations**
Application Section:	**2.5.4**
Date of RAI Issued:	**05/14/2015**

Question No. 02.05.04-6

Table 2.0-1 lists the Minimum Dynamic Shear Modulus with units of kilograms over squared centimeters (kg/cm^2). In accordance with 10 CFR parts 50 and 100 and SRP 2.5.4, please clarify if these values are meant to have the aforementioned units, kg/cm^2, or if they correspond to Normalized Shear Moduli (G/Gmax) which are unit-less; and propose changes or updates to Table 2.0-1, if applicable.

Response

The Normalized Shear Moduli (G/Gmax) should be unit-less and not kg/cm^2. The 'Backfill Material Dynamic Properties' in DCD Tier 2 Table 2.0-1 and Tier 1 Table 2.1- will be updated as indicated on the attached markup.

Impact on DCD

DCD Table 2.0-1 and the associated Tier 1 Table 2.1-1 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.

Table 2.0-1 (3 of 4)

Parameter Description	Parameter Value
Certified Seismic Design Response Spectra (CSDRS) Referencing SSE	See Figures 2.0-1 and 2.0-2
Hard Rock High Frequency (HRHF) Response Spectra(4)	0.46g peak ground acceleration See Figures 2.0-3 and 2.0-4
Fault Displacement Potential (yes/no)	No
Minimum Allowable Static Bearing Demand	718.2 kPa (15 ksf)(3)
Minimum Allowable Dynamic Bearing Demand	2,872.8 kPa (60 ksf)(3)
Minimum Shear Wave Velocity	304.8 m/s (1,000 ft/s)
Liquefaction Potential (yes/no)	No
Maximum Differential Settlement inside Building	12.7 mm (0.5 in) per 15.24 m (50 ft) in any direction
Maximum Differential Settlement between Buildings	12.7 mm (0.5 in)
Minimum Soil Angle of Internal Friction	35 degrees
Slope Failure Potential (yes/no)	No
Backfill Material Density	137 pcf
Backfill Material Dynamic Poisson's Ratio	0.33
Backfill Material Dynamic Properties ~~(Minimum Dynamic Shear Modulus, kg/cm^2)~~ ~~- Shear strain~~ ~~1 %~~ ~~0.1 %~~ ~~0.01 %~~ ~~0.001 %~~ ~~0.0001 %~~	~~0.05~~ ~~0.22~~ ~~0.54~~ ~~0.85~~ ~~1.00~~

(Normalized Shear Moduli & Damping)

Shear Strain (%)	G/G_{max}	Damping (%)
1.0	0.05	24.0
0.1	0.22	16.0
0.01	0.54	6.0
0.001	0.85	2.0
0.0001	1.00	1.0

Table 2.0-1 (4 of 4)

Parameter Description	Parameter Value
~~Backfill Material Dynamic Properties (Minimum Damping Ratio, %)~~ ~~- Shear strain~~ ~~1 %~~ ~~0.1 %~~ ~~0.01 %~~ ~~0.001 %~~ ~~0.000 1%~~	 ~~24~~ ~~16~~ ~~6~~ ~~2~~ ~~1~~
Strain-compatible Minimum Shear-wave Velocity of Backfill	510 fps

(1) Plant grade represents the level of ground adjacent to the nuclear island buildings and is established at a plant elevation 98 ft 8 in.

(2) 100-year recurrence interval: Value to be used for design of seismic Category I and II structures only.

(3) Bearing capacity is defined at the foundation level of the nuclear island structures.

(4) The HRHF response spectra are provided for evaluation of site-specific ground motion response spectra which exceed the CSDRS in the high frequency range at hard rock sites.

Table 2.1-1 (2 of 3)

Tornado	
Maximum Tornado Wind Speed	102.8 m/s (230 mph)
Translational Speed	20.6 m/s (46 mph)
Maximum Rotational Speed	82.2 m/s (184 mph)
Radius of Maximum Rotational Speed	45.7 m (150 feet)
Pressure Drop	8.274 kPa (1.2 psi)
Rate of Pressure Drop	3.447 kPa/s (0.5 psi/s)
Missile Spectra	Table 2 (Region I) of NRC RG 1.76 (2007)
Hurricane	
Maximum 3-Second Wind Gust Speed	116 m/s (260 mph)
Missile Spectra	Table 1 of NRC RG 1.221 (2011)
Soil Properties	
Minimum Allowable Static Bearing Demand	718.2 kPa (15 ksf) (3)
Minimum Allowable Dynamic Bearing Demand	2,872.8 kPa (60 ksf) (3)
Minimum Shear Wave Velocity	304.8 m/s (1,000 ft/sec)
Liquefaction Potential (yes/no)	No
Maximum Differential Settlement inside Building	12.7 mm (0.5 in) per 15.24 m (50 ft) in any direction
Maximum Differential Settlement between Buildings	12.7 mm (0.5 in)
Minimum Soil Angle of Internal Friction	35 degrees
Slope Failure Potential (yes/no)	No
Fault Displacement Potential (yes/no)	No
Backfill Material Density	137 pcf
Backfill Material Dynamic Poisson's Ratio	0.33
Backfill Material Dynamic Properties ~~(Minimum Dynamic Shear Modulus, kg/cm^2)~~ ~~- Shear Strain~~	
~~• 1%~~ ~~• 0.1%~~ ~~• 0.01%~~ ~~• 0.001%~~ ~~• 0.0001%~~	~~0.05~~ ~~0.22~~ ~~0.54~~ ~~0.85~~ ~~1.00~~

(Normalized Shear Moduli & Damping)

Shear Strain (%)	G/G_{max}	Damping (%)
1.0	0.05	24.0
0.1	0.22	16.0
0.01	0.54	6.0
0.001	0.85	2.0
0.0001	1.00	1.0

Table 2.1-1 (3 of 3)

Soil Properties (Cont'd)	
Backfill Material Dynamic Properties (Minimum Damping Ratio, %) - Shear Strain • 1% • 0.1% • 0.01% • 0.001% • 0.0001%	 24 16 6 2 1
Strain-compatible Minimum Shear-wave velocity of Backfill	510 fps
Seismology	
Safe Shutdown Earthquake (SSE)	0.3g peak ground acceleration
Certified Seismic Design Response Spectra (CSDRS) Referencing SSE	See Figures 2.1-1 and 2.1-2
Hard Rock High Frequency (HRHF) Response Spectra(4)	0.46g peak ground acceleration See Figures 2.1-3 and 2.1-4
Meteorology	
Accident Release χ/Q Values at EAB · 0-2 hr	 1.00×10^{-3} s/m^3
Accident Release χ/Q Values at LPZ · 0-8 hr · 8-24 hr · 24-96 hr · 96-720 hr	 2.20×10^{-4} s/m^3 1.60×10^{-4} s/m^3 1.00×10^{-4} s/m^3 8.00×10^{-5} s/m^3
Meteorology (Cont'd)	
Annual Average χ/Q Values at Site Boundary · Undepleted/No Decay · Undepleted/2.26-Day Decay · Depleted/8.00-Day Decay · D/Q	 2.00 × 10-5 s/m^3 1.99 × 10-5 s/m^3 1.84 × 10-5 s/m^3 2.00 × 10-7 /m^2
Inventory of Radionuclides Which Could Potentially Seep into the Groundwater	See Table 2.1-2

(1) Plant grade represents the level of ground adjacent to the nuclear island buildings and is established plant elevation of 98 ft 8 in.

(2) 100-year recurrence interval; value to be used for design of seismic Category I and II structures only.

(3) Bearing capacity is defined at the foundation level of the Nuclear Island Structures.

(4) The HRHF response spectra are provided for evaluation of site-specific ground motion response spectra which exceed the CSDRS in the high frequency range at hard rock sites.

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.:	**8-7847**
SRP Section:	**02.05.04 – Stability of Subsurface Materials and Foundations**
Application Section:	**2.5.4**
Date of RAI Issued:	**05/14/2015**

Question No. 02.05.04-7

APR 1400 DCD Section 2.5.4.8 states that no potential for liquefaction is allowed for Seismic Category I Structures and that the potential for liquefaction under non-seismic Category I structure is a site specific issue to be addressed by the COL applicant. In accordance with 10 CFR Parts 50, 52.47 and 100, please address the following and propose changes and updates to section 2.5.4.8 and Table 2.0-1:

a. For Seismic Category I structures (Nuclear Island, EDG and DFOT structures), clarity the location where no potential for liquefaction is allowed (i.e. underneath, adjacent, etc.)

b. Due to the fact that the possible structural failure of Seismic Category II structures could degrade the function of a Seismic Category I SSC to an unacceptable safety level, please provide requirements for liquefaction potential for Seismic Category II Structures.

Response

a. No liquefaction potential is allowed for the foundation at the site adjacent to and under seismic Category I structures. Subsection 2.5.4.8 will be revised to clarify the location where no liquefaction potential is allowed and also to provide reference to RG 1.198 for the liquefaction evaluation to be performed by the COL applicant.

b. For those seismic Category II structures that have the potential to degrade the function of a seismic Category I SSC to an unacceptable safety level, it will be required that the COL applicant address the liquefaction potential for the foundation of those identified seismic Category II structures. Subsection 2.5.4.8 will be revised to include the requirement for reviewing liquefaction potential for some seismic Category II structures.

Impact on DCD

DCD Subsections 2.5.4.8, 2.5.6, 2.5.7 and associated tables 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.

2.5.4.8 Liquefaction Potential

~~As specified in Table 2.0-1, no potential for liquefaction is allowed for seismic Category I structures. The potential liquefaction under non-seismic Category I structures is a site-specific issue to be addressed by combined operating license applicants.~~

No liquefaction potential is allowed for the foundation at the site adjacent to and under seismic Category I structures. The COL applicant is to evaluate the potential for liquefaction occurring at the site in accordance with NRC RG 1.198. In addition, the COL applicant is to evaluate the liquefaction potential for those seismic Category II structure foundations that if failed, could degrade the function of a seismic Category I SSC to an unacceptable safety level (COL 2.5(13)).

2.5.4.9 Earthquake Site Characteristics

The earthquake site-specific characteristics are described in Subsection 2.5.2.

2.5.4.10 Static

Bearing capaci
strength, and el
are provided.

An evaluation of lateral earth pressures and hydrostatic groundwater loads acting on plant facilities is provided. Foundation information on seismic Category I structures is provided in Subsection 3.8.5.

An analysis is conducted using a two-dimensional or three-dimensional model.

2.5.4.11 Design Criteria

The criteria for the factor of safety (FS) for the safety analysis of foundation rock and slope that may affect seismic Category I facilities are as follows:

Criterion	Factor of Safety
Bearing Capacity	
Ultimate capacity	$FS \geq 3.0$
Transient loading	$FS \geq 2.0$
Maximum localized stress	$FS \geq 1.2$
Slope	
Static condition	$FS \geq 1.5$
Dynamic condition	$FS \geq 1.2$

The design criteria used in the stability studies of all safety-related facilities, including a description of the computer programs used in the analyses and the soil loads, are provided.

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 2.5(2) and COL 2.5(3) above are not met. In addition, the COL applicant is to confirm that the site-specific in-structure response spectra so generated are enveloped by the corresponding in-structure response spectra provided in Appendix 3.7A.

COL 2.5(6) The COL applicant is to perform a site-specific seismic response analysis using the procedure described in Appendix 3.7B and the EPRI White Paper "Seismic Screening of Components Sensitive to High Frequency Vibratory Motions" (Reference 6), if COL 2.5(4) is not met.

COL 2.5(7) 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(8) The COL applicant is to confirm that the dynamic properties of SFG to be used in construction of the APR1400 seismic Category I structures satisfy the SFG requirements provided in Table 2.0-1.

COL 2.5(13) The COL applicant is to evaluate the potential for liquefaction occurring at the site adjacent to and under seismic Category I structures in accordance with NRC RG 1.198. In addition, the COL applicant is to evaluate the liquefaction potential for those seismic Category II structure foundations that if failed, could degrade the function of a seismic Category I SSC to an unacceptable safety level.

2.5.7 References

1. Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants," U.S. N

2. Regula

Plants,

3. Regulatory Guide 1.138, "Laboratory Investigations of Soils and Rocks for Engineering Analysis and Design of Nuclear Power Plants," Rev. 2, U.S. Nuclear Regulatory Commission, December 2003.

4. Regulatory Guide 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion," U.S. Nuclear Regulatory Commission, March 2007.

5. NRC DC/COL-ISG-017, "Interim Staff Guidance on Ensuring Hazard-Consistent Seismic Input for Site Response and Soil Structure Interaction Analyses," U.S. Nuclear Regulatory Commission, August 2009.

6. "Seismic Screening of Components Sensitive to High Frequency Vibratory Motions," EPRI White Paper, June 2007.

7. NUREG/CR-0693, "Seismic Input and Soil-Structure Interaction," U.S. Nuclear Regulatory Commission, February 1979.

9. Regulatory Guide 1.198, "Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plant Sites," U.S. Nuclear Regulatory Commission, November 2003.

Table 2.0-1 (3 of 4)

Parameter Description	Parameter Value
Certified Seismic Design Response Spectra (CSDRS) Referencing SSE	See Figures 2.0-1 and 2.0-2
Hard Rock High Frequency (HRHF) Response Spectra(4)	0.46g peak ground acceleration See Figures 2.0-3 and 2.0-4
Fault Displacement Potential (yes/no)	No
Minimum Allowable Static Bearing Demand	718.2 kPa (15 ksf)(3)
Minimum Allowable Dynamic Bearing Demand	2,872.8 kPa (60 ksf)(3)
Minimum Shear Wave Velocity	304.8 m/s (1,000 ft/s)
Liquefaction Potential ~~(yes/no)~~	~~No~~ See Subsection 2.5.4.8
Maximum Differential Settlement inside Building	12.7 mm (0.5 in) per 15.24 m (50 ft) in any direction
Maximum Differential Settlement between Buildings	12.7 mm (0.5 in)
Minimum Soil Angle of Internal Friction	35 degrees
Slope Failure Potential (yes/no)	No
Backfill Material Density	137 pcf
Backfill Material Dynamic Poisson's Ratio	0.33
Backfill Material Dynamic Properties (Minimum Dynamic Shear Modulus, kg/cm^2) - Shear strain	
1 %	0.05
0.1 %	0.22
0.01 %	0.54
0.001 %	0.85
0.0001 %	1.00

Table 2.1-1 (2 of 3)

Tornado	
Maximum Tornado Wind Speed	102.8 m/s (230 mph)
Translational Speed	20.6 m/s (46 mph)
Maximum Rotational Speed	82.2 m/s (184 mph)
Radius of Maximum Rotational Speed	45.7 m (150 feet)
Pressure Drop	8.274 kPa (1.2 psi)
Rate of Pressure Drop	3.447 kPa/s (0.5 psi/s)
Missile Spectra	Table 2 (Region I) of NRC RG 1.76 (2007)
Hurricane	
Maximum 3-Second Wind Gust Speed	116 m/s (260 mph)
Missile Spectra	Table 1 of NRC RG 1.221 (2011)
Soil Properties	
Minimum Allowable Static Bearing Demand	718.2 kPa (15 ksf) (3)
Minimum Allowable Dynamic Bearing Demand	2,872.8 kPa (60 ksf) (3)
Minimum Shear Wave Velocity	304.8 m/s (1,000 ft/sec)
Liquefaction Potential ~~(yes/no)~~	~~No~~ See Tier 2 Subsection 2.5.4.8
Maximum Differential Settlement inside Building	12.7 mm (0.5 in) per 15.24 m (50 ft) in any direction
Maximum Differential Settlement between Buildings	12.7 mm (0.5 in)
Minimum Soil Angle of Internal Friction	35 degrees
Slope Failure Potential (yes/no)	No
Fault Displacement Potential (yes/no)	No
Backfill Material Density	137 pcf
Backfill Material Dynamic Poisson's Ratio	0.33
Backfill Material Dynamic Properties (Minimum Dynamic Shear Modulus, kg/cm^2) - Shear Strain	
• 1% • 0.1% • 0.01% • 0.001% • 0.0001%	0.05 0.22 0.54 0.85 1.00

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 2.5(2) and COL 2.5(3) above are not met. In addition, the COL applicant is to confirm that the site-specific in-structure response spectra so generated are enveloped by the corresponding in-structure response spectra provided in Appendix 3.7A.
COL 2.5(6)	The COL applicant is to perform a site-specific seismic response analysis using the procedure described in Appendix 3.7B and the EPRI White Paper, "Seismic Screening of Components Sensitive to High Frequency Vibratory Motions," if COL 2.5(4) is not met.
COL 2.5(7)	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(8)	The COL applicant is to confirm that the dynamic properties of structural fill granular to be used in construction of the APR1400 seismic Category I structures satisfy the requirements of structural fill granular provided in Table 2.0-1.
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.

COL 2.5(13) The COL applicant is to evaluate the potential for liquefaction occurring at the site adjacent to and under seismic Category I structures in accordance with NRC RG 1.198. In addition, the COL applicant is to evaluate the liquefaction potential for those seismic Category II structure foundations that if failed, could degrade the function of a seismic Category I SSC to an unacceptable safety level.

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.:	**RAI 8-7847**
SRP Section:	**02.05.04 - Stability of Subsurface Materials and Foundations**
Application Section:	**2.5.4**
Date of RAI Issued:	**05/14/2015**

Question No. 02.05.04-8

Section 3.7.1.3 of the APR 1400 DCD states that the Emergency Diesel Generator Building (EDG) and the Diesel Fuel Oil Storage Tank room (DFOT) are Seismic Category I structures. The static and dynamic parameters for the aforementioned structures are not included in Table 2.0-1. In accordance with 10 CFR parts 50 and 100 and SRP 2.5.4, please propose changes to section 2.5.4.10 and updates to Table 2.0-1 with the following information:

a. Static and Dynamic Bearing Capacities for the EDG and DFOT buildings with their respective Factors of Safety (FOS).

b. Maximum Differential Settlement inside the EDG and DFOT buildings.

c. Maximum Differential Settlement between the EDG and DFOT buildings; and between the rest of adjacent buildings.

Response

a. The maximum bearing pressure beneath EDG building basemat is 387.8 kPa (8.10 ksf), which includes the dead weight (structures and components) and live load. According to Table 2.0-1, the allowable static bearing capacity shall be greater than or equal to the maximum static bearing demand of 718.2 kPa (15.0 ksf). Since the ultimate bearing capacity is more than three times the maximum static bearing demand, the FOS will be greater than 3.0.

The maximum bearing pressure beneath EDG building basemat for safe shutdown earthquake loads combined with static loads is 671.3 kPa (14.02 ksf). According to Table 2.0-1, the allowable dynamic bearing capacity shall be greater than or equal to the maximum dynamic bearing demand of 2,872.8 kPa (60.0 ksf). Since the ultimate bearing capacity is more than two times the maximum dynamic bearing demand, the FOS will be greater than 2.0.

The maximum bearing pressure beneath DFOT building basemat is 306.9 kPa (6.41 ksf), which includes the dead weight (structures and components) and live load according to Table 2.0-1, the allowable static bearing capacity shall be greater than or equal to the maximum static bearing demand of 718.2 kPa (15.0 ksf). Since the ultimate bearing capacity is more than three times the maximum static bearing demand, the FOS will be greater than 3.0.

The maximum bearing pressure beneath DFOT building basemat for safe shutdown earthquake loads combined with static loads is 248.5 kPa (5.10 ksf). According to Table 2.0-1, the allowable dynamic bearing capacity shall be greater than or equal to the maximum dynamic bearing demand of 2,872.8 kPa (60.0 ksf). Since the ultimate bearing capacity is more than two times the maximum dynamic bearing demand, the FOS will be greater than 2.0.

DCD Subsections 2.5.4.11 and Table 2.0-1 will be revised to clarify the allowable bearing capacity of the EDG and DFOT buildings. In addition, COL Item 2.5(11) will be revised to reflect a site specific evaluation when the allowable bearing capacity is determined to be less than the maximum bearing demand value provided in Table 2.0-1. These DCD sections were previously updated to reflect the response of RAI 1-7827 Question 02.05.04-2 (Reference ML15132A592). Changes made as a result of this RAI response have been incorporated into the previously submitted markups and are attached.

b. The maximum differential settlements inside the EDG building and the DFOT building were provided in Table 3.8A-39. The following description for the maximum differential settlement inside the EDG building and the DFOT building will be added to Subsection 3.8A.3.4.1 since that section describes the settlement checks for those buildings.

The distance of approximately 15.24 m (50 ft) is selected to check the differential settlement. Table 3.8A-39 shows the differential settlements of each soil profile. The maximum differential settlement for the EDG building per 15.24 m (50 ft) is 4.52 mm (0.18 in). The maximum differential settlement for DFOT building per 15.24 m (50 ft) is 7.21 mm (0.28 in).

c. The maximum differential settlements between the EDG building, the DFOT building, and other adjacent buildings are as follows:

The differential settlement of each soil profiles between the NI common basemat and EDG building is checked. The maximum differential settlement between the NI common basemat and EDG building is 58.14 mm (2.29 in).

The differential settlement of each soil profiles between the NI common basemat and DFOT building is checked. The maximum differential settlement between the NI common basemat and DFOT building is 53.32 mm (2.10 in).

The differential settlement of each soil profiles between the EDG building and DFOT building is checked. The maximum differential settlement between the EDG building and DFOT building is 4.83 mm (0.19 in).

Subsection 3.8A.3.4.1 will be revised to incorporate the clarification of differential settlements between buildings.

Impact on DCD

DCD Tier 2 Table 2.0-1, Subsection 2.5.4.11, COL Item 2.5(11), and Subsection 3.8A.3.4.1 along with Tier 1 Table 2.1-1 will be revised as indicated on the attached markup to provide a summary of differential settlements.

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.

2.5.4.8 Liquefaction Potential

As specified in Table 2.0-1, no potential for liquefaction is allowed for seismic Category I structures. The potential liquefaction under non-seismic Category I structures is a site-specific issue to be addressed by combined operating license applicants.

2.5.4.9 Earthquake Site Characteristics

The earthquake site-specific characteristics are described in Subsection 2.5.2.

2.5.4.10 Static Stability

Bearing capacity analysis and settlement computation using stratigraphic conditions, strength, and elastic parameters of the rock mass, building loads, and structural interfaces are provided.

and factor of safety (FOS) of stability

An evaluation of lateral earth pressures and hydrostatic groundwater loads acting on plant facilities is provided. Foundation information on seismic Category I structures is provided in Subsection 3.8.5.

An analysis is conducted using a two-dimensional or three-dimensional model.

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2.5.4.11 Design Criteria

The criteria for the factor of safety (FS) for the safety analysis of foundation rock and slope that may affect seismic Category I facilities are as follows:

Criterion	Factor of Safety
Bearing Capacity	
Ultimate capacity	FS ≥ 3.0
Transient loading	FS ≥ 2.0
Maximum localized stress	FS ≥ 1.2
Slope	
Static condition	FS ≥ 1.5
Dynamic condition	FS ≥ 1.2

The design criteria used in the stability studies of all safety-related facilities, including a description of the computer programs used in the analyses and the soil loads, are provided.

Note : No change as a result of 02.05.04-8

2.5.4.10.1 Bearing Capacity

The maximum bearing pressure under static loading conditions for the foundation basemat beneath the Seismic Category I structure (reactor containment building, auxiliary building, emergency diesel generator building and diesel fuel oil tank) is 641.5 kPa (13,397 lb/ft^2), which includes the dead weight of the structure and components and live load. The maximum bearing pressure under safe shutdown earthquake loads combined with static loads, as described in Subsection 3.8.5, is 1415.9 kPa (29,572 lb/ft^2) (Reference 8). The maximum bearing pressure is smaller than the ~~maximum bearing demands~~ specified in Table 2.0-1.

allowable bearing capacity

The COL applicant will evaluate the allowable bearing capacity of the subsurface based on the site-specific properties of the underlying materials, including appropriate laboratory test data to evaluate strength, and considering local site effects, such as fracture spacing, variability in properties, and evidence of shear zones. If the site-specific allowable bearing capacity is outside the range evaluated for APR1400 design certification or smaller than the maximum bearing demands specified in Table 2.0-1, a site-specific evaluation shall be performed by a COL applicant using the APR1400 basemat model and methodology described in subsection 3.8.5(COL 2.5(11)).

2.5.4.10.2 Settlement

The safety-related structures of APR1400 are reactor containment building, auxiliary building, emergency diesel generator building, and diesel fuel oil tank. Based on the distributed arrangement of safety-related systems and components, there are some restricted interfaces between systems which communicate between or within buildings. The effect of total settlement and differential settlement will be considered where these interfaces occur.

Total settlement and differential settlement is dependent on site-specific conditions, construction sequence, loading condition, and excavation plans. It is expected that most of this settlement occurs during civil construction prior to final installation of the equipment. Site-specific considerations for the predicted settlement will be taken into account. Site-specific considerations include the effects of excavation, foundation material preparation, sequence of concrete placement of the basemat, and site-specific construction sequence of the superstructure.

The COL applicant will verify whether the predicted settlement exceeds the maximum differential settlement within building specified in Table 2.0-1 or not. If the predicted settlement exceeds the maxim ... OL applica ... to demon ...

The allowable bearing capacity of soil under foundation is the value of ultimate bearing capacity divided by FOS. For bearing capacity, the required FOS is greater than or equal to 3.0 for the static condition and greater than or equal to 2.0 for the dynamic condition including SSE load.

2.5.4.11 Design Criteria

The criteria for the factor of safety (FOS) for the safety analysis of foundation soil and slope that may affect seismic Category I facilities are shown in Table 2.0-1.

~~For bearing capacity of soil under foundation, the required FOS is greater than or equal to 3.0 for static condition and the required FOS is greater than or equal to 2.0 for dynamic condition including SSE load.~~

For slope, the required FOS is greater than or equal to 1.5 for static condition and the required FOS is greater than or equal to 1.2 for dynamic condition including SSE load.

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 2.5(2) and COL 2.5(3) above are not met. In addition, the COL applicant is to confirm that the site-specific in-structure response spectra so generated are enveloped by the corresponding in-structure response spectra provided in Appendix 3.7A.

COL 2.5(6) The COL applicant is to perform a site-specific seismic response analysis using the procedure described in Appendix 3.7B and the EPRI White Paper "Seismic Screening of Components Sensitive to High Frequency Vibratory Motions" (Reference 6), if COL 2.5(4) is not met.

COL 2.5(7) 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(8) The COL applicant is to confirm that the dynamic properties of SFG to be used in construction of the APR1400 seismic Category I structures satisfy the SFG requirements provided in Table 2.0-1.

COL 2.5(11) The COL applicant will evaluate the allowable bearing capacity of the subsurface based on the site-specific properties of the underlying materials, including appropriate laboratory test data to evaluate strength, and considering local site effects, such as fracture spacing, variability in properties, and evidence of shear zones. If the site-specific allowable bearing capacity is ~~outside the range evaluated for APR1400 design certification or smaller~~ less than the maximum bearing demands specified in Table 2.0-1, a site-specific evaluation shall be performed by a COL applicant using the APR1400 basemat model and methodology described in subsection 3.8.5.

COL 2.5(12) The COL applicant will verify whether the predicted settlement exceeds the maximum differential settlement within building specified in Table 2.0-1 or not. If the predicted settlement exceeds the maximum value in Table 2.0-1, a detailed site specific evaluation shall be performed by a COL applicant using the APR1400 basemat model and methodology described in subsection 3.8.5 to demonstrate acceptable.

2.5.7 References

1. Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, June 2007.

2. Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plant

3. Regu
Engi
Regu

4. Regu
Earth

5. NRC
Seism
Regu

6. “Seismic Screening of Components Sensitive to High Frequency Vibratory Motions,” EPRI White Paper, June 2007.

7. NUREG/CR-0693, "Seismic Input and Soil-Structure Interaction," U.S. Nuclear Regulatory Commission, February 1979.

8. APR1400-E-S-NR-14006-P, "Stability Check for NI Common Basemat" Rev.1, KHNP, February 2015.

Note : No change as a result of 02.05.04-8

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
COL	
COL	
COL	2.5(2) and COL 2.5(3) above are not met. In addition, the COL applicant is to confirm that the site-specific in-structure response spectra so generated are enveloped by the corresponding in-structure response spectra provided in Appendix 3.7A.
COL 2.5(6)	The COL applicant is to perform a site-specific seismic response analysis using the procedure described in Appendix 3.7B and the EPRI White Paper, "Seismic Screening of Components Sensitive to High Frequency Vibratory Motions," if COL 2.5(4) is not met.
COL 2.5(7)	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(8)	The COL applicant is to confirm that the dynamic properties of structural fill granular to be used in construction of the APR1400 seismic Category I structures satisfy the requirements of structural fill granular provided in Table 2.0-1.
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.

COL 2.5(11) The COL applicant will evaluate the allowable bearing capacity of the subsurface based on the site-specific properties of the underlying materials, including appropriate laboratory test data to evaluate strength, and considering local site effects, such as fracture spacing, variability in properties, and evidence of shear zones. If the site-specific allowable bearing capacity is ~~outside the range evaluated for APR1400 design certification or smaller~~ less than the maximum bearing demands specified in Table 2.0-1, a site-specific evaluation shall be performed by a COL applicant using the APR1400 basemat model and methodology described in subsection 3.8.5.

COL 2.5(12) The COL applicant will verify whether the predicted settlement exceeds the maximum differential settlement within building specified in Table 2.0-1 or not. If the predicted settlement exceeds the maximum value in Table 2.0-1, a detailed site specific evaluation shall be performed by a COL applicant using the APR1400 basemat model and methodology described in subsection 3.8.5 to demonstrate acceptable.

The allowable static bearing capacity, including a factor of safety appropriate for the design load combinations, shall be greater than or equal to the maximum static bearing demand of 718.2 kPa (15 ksf).

~~The allowable static bearing capacity, including a factor of safety 3.0, shall be greater than or equal to the maximum static bearing demand.~~

Table 2.0-1 (3 of 4)

Allowable Static Bearing Capacity

~~Maximum~~

Parameter Description	Parameter
Certified Seismic Design Response Spectra (CSDRS) Referencing SSE	See Figures 2.0-1 and 2.0-2
Hard Rock High Frequency (HRHF) Response Spectra(4)	0.46g peak ground acceleration See Figures 2.0-3 and 2.0-4
Fault Displacement Potential (yes/no)	No
~~Minimum Allowable Static Bearing Demand~~	~~718.2 kPa (15 ksf)~~(3)
~~Minimum Allowable Dynamic Bearing Demand~~	~~2,872.8 kPa (60 ksf)~~(3)
Minimum Shear Wave Velocity	304.8 m/s (1,000 ft/s)
Liquefaction Potential (yes/no)	No
Maximum Differential Settlement inside Building	12.7 mm (0.5 in) per 15.24 m (50 ft) in any direction
Maximum Differential Settlement between Buildings	12.7 mm (0.5 in)
Minimum Soil Angle of Internal Friction	35 degrees
Slope Failure Potential (yes/no)	No
Backfill Material Density	137 pcf
Backfill Material Dynamic Poisson's Ratio	0.33
Backfill Material Dynamic Properties (Minimum Dynamic Shear Modulus, kg/cm^2)	
- Shear strain	
1 %	[illegible]
0.1 %	[illegible]
0.01 %	[illegible]
0.001 %	0.85
0.0001 %	1.00

Allowable Dynamic Bearing Capacity

~~The allowable dynamic bearing capacity, including a factor of safety 2.0, shall be greater than or equal to the maximum dynamic bearing demand.~~

The allowable dynamic bearing capacity, including a factor of safety appropriate for the design load combinations, shall be greater than or equal to the maximum dynamic bearing demand of 2,872.8 kPa (60 ksf).

Minimum Factor of Safety for Slope on Static condition	1.5
Minimum Factor of Safety for Slope on Dynamic condition (SSE)	1.2

Table 2.0-1 (4 of 4)

Parameter Description	Parameter Value
Backfill Material Dynamic Properties (Minimum Damping Ratio, %) - Shear strain 1 % 0.1 % 0.01 % 0.001 % 0.000 1%	 24 16 6 2 1
Strain-compatible Minimum Shear-wave Velocity of Backfill	510 fps

(1) Plant grade represents the level of ground adjacent to the nuclear island buildings and is established at a plant elevation 98 ft 8 in.

(2) 100-year recurrence interval: Value to be used for design of seismic Category I and II structures only.

(3) Bearing capacity is defined at the foundation level of the ~~nuclear island~~ seismic Category I structures.

(4) The HRHF response spectra are provided for evaluation of site-specific ground motion response spectra which exceed the CSDRS in the high frequency range at hard rock sites.

Table 2.1-1 (2 of 3)

Tornado	
Maximum Tornado Wind Speed	102.8 m/s (230 mph)
Translational Speed	20.6 m/s (46 mph)
Maximum Rotational Speed	82.2 m/s (184 mph)
Radius of Maximum Rotational Speed	45.7 m (150 feet)
Pressure Drop	8.274 kPa (1.2 psi)
Rate of Pressure Drop	3.447 kPa/s (0.5 psi/s)
Missile Spectra	Table 2 (Region I) of NRC RG 1.76 (2007)
Hurricane	
Maximum 3-Second Wind Gust Speed	116 m/s (260 mph)
Missile Spectra	Table 1 of NRC RG 1.221 (2011)
Soil Properties	
~~Minimum Allowable Static Bearing Demand~~	~~718.2 kPa (15 ksf)~~ (3)
~~Minimum Allowable Dynamic Bearing Demand~~	~~2,872.8 kPa (60 ksf)~~ (3)
Minimum Shear Wave Velocity	304.8 m/s (1,000 ft/sec)
Liquefaction Potential (yes/no)	No
Maximum Differential Settlement inside Building	12.7 mm (0.5 in) per 15.24 m (50 ft) in any direction
Maximum Differential Settlement between Buildings	12.7 mm (0.5 in)
Minimum Soil Angle of Internal Friction	35 degrees
Slope Failure Potential (yes/no)	No
Fault Displacement Potential (yes/no)	No
Backfill Material Density	137 pcf
Backfill Material Dynamic Poisson's Ratio	0.33
Backfill Material Dynamic Properties (Minimum Dynamic Shear Modulus, kg/cm^2) - Shear Strain	
• 1%	
• 0.1%	
• 0.01%	
• 0.001%	0.85
• 0.0001%	1.00

Markup notes on the page:

The allowable static bearing capacity, including a factor of safety appropriate for the design load combinations, shall be greater than or equal to the maximum static bearing demand of 718.2 kPa (15 ksf).

~~The allowable static bearing capacity, including a factor of safety 3.0, shall be greater than or equal to the maximum static bearing demand.~~

Allowable Static Bearing Capacity

~~Maximum~~

Allowable Dynamic Bearing Capacity

~~The allowable dynamic bearing capacity, including a factor of safety 2.0, shall be greater than or equal to the maximum dynamic bearing demand.~~

The allowable dynamic bearing capacity, including a factor of safety appropriate for the design load combinations, shall be greater than or equal to the maximum dynamic bearing demand of 2,872.8 kPa (60 ksf).

Minimum Factor of Safety for Slope on Static condition	1.5
Minimum Factor of Safety for Slope on Dynamic condition (SSE)	1.2

Table 2.1-1 (3 of 3)

Soil Properties (Cont'd)	
Backfill Material Dynamic Properties (Minimum Damping Ratio, %) - Shear Strain • 1% • 0.1% • 0.01% • 0.001% • 0.0001%	 24 16 6 2 1
Strain-compatible Minimum Shear-wave velocity of Backfill	510 fps
Seismology	
Safe Shutdown Earthquake (SSE)	0.3g peak ground acceleration
Certified Seismic Design Response Spectra (CSDRS) Referencing SSE	See Figures 2.1-1 and 2.1-2
Hard Rock High Frequency (HRHF) Response Spectra(4)	0.46g peak ground acceleration See Figures 2.1-3 and 2.1-4
Meteorology	
Accident Release χ/Q Values at EAB · 0-2 hr	 1.00×10^{-3} s/m^3
Accident Release χ/Q Values at LPZ · 0-8 hr · 8-24 hr · 24-96 hr · 96-720 hr	 2.20×10^{-4} s/m^3 1.60×10^{-4} s/m^3 1.00×10^{-4} s/m^3 8.00×10^{-5} s/m^3
Meteorology (Cont'd)	
Annual Average χ/Q Values at Site Boundary · Undepleted/No Decay · Undepleted/2.26-Day Decay · Depleted/8.00-Day Decay · D/Q	 2.00 × 10-5 s/m^3 1.99 × 10-5 s/m^3 1.84 × 10-5 s/m^3 2.00 × 10-7 /m^2
Inventory of Radionuclides Which Could Potentially Seep into the Groundwater	See Table 2.1-2

(1) Plant grade represents the level of ground adjacent to the nuclear island buildings and is established plant elevation of 98 ft 8 in.

(2) 100-year recurrence interval; value to be used for design of seismic Category I and II structures only.

(3) Bearing capacity is defined at the foundation level of the ~~Nuclear Island~~ Structures. [inserted: seismic Category I]

(4) The HRHF response spectra are provided for evaluation of site-specific ground motion response spectra which exceed the CSDRS in the high frequency range at hard rock sites.

FAC	flow-accelerated corrosion
FACT	fuel assembly compatibility test
FAP	fuel alignment plate
FATT	fracture appearance transition temperature
FC	fully closed
FCAW	flux cored arc welding
FCI	fuel-coolant interaction
FCR	field change request
FDS	floor drain system
FDT	1) floor drain tank 2) functional definition table
FEI	fluid-elastic instability
FEM	finite element model
FF	flash fraction
FHA	1) fuel handling accident 2) fuel handling area 3) fire hazards analysis
FHAEES	fuel handling area emergency exhaust system
FHEVAS	fuel handling area emergency ventilation actuation signal
FHS	fuel handling system
FIDAS	fixed in-core detector amplification system
FIRS	foundation input response spectra
FIV	flow-induced vibration
FLB	feedwater line break
FLC	factored load category
FLEX	diverse and flexible coping strategies
FME	foreign material exclusion
FMEA	failure modes and effects analysis
FO	fully open
FOM	fiber optic modem
FP	fire protection

FOS factor of safety

Note : No change as a result of 02.05.04-8

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.~~

The distance of approximately 15.24 m (50 ft) is selected to check the differential settlement. Table 3.8A-39 shows the differential settlements of each soil profile. The maximum differential settlement for EDG building per 15.24 m (50 ft) is 4.52 mm (0.18 in). The maximum differential settlement for DFOT building per 15.24 m (50 ft) is 7.21 mm (0.28 in).

The differential settlement of each soil profiles between the NI common basemat and EDG building is checked. The maximum differential settlement between the NI common basemat and EDG building is 58.14 mm (2.29 in).

The differential settlement of each soil profiles between the NI common basemat and DFOT building is checked. The maximum differential settlement between the NI common basemat and DFOT building is 53.32 mm (2.10 in).

The differential settlement of each soil profiles between the EDG building and DFOT building is checked. The maximum differential settlement between the EDG building and DFOT building is 4.83 mm (0.19 in).

3.8A.3.4.2

Description

The shear wa... resisting syste... slab distribute... in proportion ... transferred do... shear walls.

The in-plane ... results, are co... distribution of vertical and horizontal reinforcing steel of the EDG building shear walls.

Note : This page not changed in previous RAI 1-7827 Question 02.05.04-2.

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.:	**RAI 8-7847**
SRP Section:	**02.05.04 - Stability of Subsurface Materials and Foundations**
Application Section:	**2.5.4**
Date of RAI Issued:	**05/14/2015**

Question No. 02.05.04-9

Table 2.0-1 lists values for “Minimum Allowable Static Bearing Demand” and “Minimum Allowable Dynamic Bearing Demand”. Generally, “demand”, as it relates to foundation engineering, refers to the pressure caused by the weight of the structure and the loads (static or dynamic) acting on the foundation exert on the supporting soil. Conversely, “capacity” refers to the pressure at which shear failure in soil can occur. In accordance with 10 CFR Parts 50 and 100 and SRP 2.5.4, please provide the following information and propose changes and updates to sections of 2.5.4.10 and Table 2.0-1:

a. Clarification on what exactly is meant by the word “demand” in the aforementioned values in Table 2.0-1

b. Static Bearing Capacity and associated Factor of Safety for the Nuclear Island

c. Dynamic Bearing Capacity and associated Factor of Safety for the Nuclear Island

Response

a. The “demand” means the pressure caused by the weight of the structure and the loads (static or dynamic) acting on the foundation. Because the words ‘Minimum Allowable’ used in the ‘Minimum Allowable Static Bearing Demand’ and ‘Minimum Allowable Dynamic Bearing Demand’ creates ambiguity in the terminology ‘Bearing Demand’, the expressions were revised to ‘Allowable Static Bearing Capacity’ and ‘Allowable Dynamic Bearing Capacity’, respectively, in the response for RAI 8-7847 Question No. 02.05.04-8.

b. The maximum bearing pressure beneath the Nuclear Island (NI) common basemat for static loading condition is 641.5 kPa (13.397 ksf), which includes the dead weight (structures and components) and live load. According to Table 2.0-1, the allowable static bearing capacity shall be greater than or equal to the maximum static bearing demand of 718.2 kPa (15.0 ksf). Since the ultimate bearing capacity is more than three times the maximum static bearing demand, the FOS will be greater than 3.0.

c. The maximum bearing pressure beneath NI common basemat for safe shutdown earthquake loads combined with static loads is 1415.9 kPa (29.572 ksf). According to Table 2.0-1, the allowable dynamic bearing capacity shall be greater than or equal to the maximum dynamic bearing demand of 2,872.8 kPa (60.0 ksf). Since the ultimate bearing capacity is more than two times the maximum dynamic bearing demand, the FOS will be greater than 2.0.

There are no recommended changes to section 2.5.4.10 or Table 2.0-1 based on this response.

Impact on DCD

There is no impact on the DCD. The response to RAI 8-7847, Question No. 02.05.04-8 provides changes to the DCD terminology discussed in part "a" of 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 and Environmental Reports.

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.:	**RAI 8-7847**
SRP Section:	**02.05.04 - Stability of Subsurface Materials and Foundations**
Application Section:	**2.5.4**
Date of RAI Issued:	**05/14/2015**

Question No. 02.05.04-10

Table 2.0-1 lists values for "Maximum Differential Settlement inside Building" and "Maximum Differential Settlement between buildings". In accordance with 10 CFR parts 50 and 100 and SRP 2.5.4, please clarify which buildings these parameters are applicable to and propose changes to Table 2.0-1

Response

a. The Maximum Allowable Differential Settlement inside Building listed in Table 2.0-1 is applicable to the following Seismic Category I structures: Reactor Containment Building, Auxiliary Building, Emergency Diesel Generator Building, and Diesel Fuel Oil Tank Building.

b. The Maximum Allowable Differential Settlement between Buildings listed in Table 2.0-1 is for Nuclear Island (NI) common basemat and other adjacent buildings with the exception of the EDG and DFOT buildings.

   Table 2.0-1 will be revised to provide the Maximum allowable differential settlement between other buildings, as discussed below:

   The maximum allowable differential settlement between the NI common basemat and the EDG and DFOT buildings is 76.2 mm (3.0 in). The maximum allowable differential settlement between the NI common basemat and other adjacent buildings is 12.7 mm (0.5 in).

Impact on DCD

DCD Table 2.0-1, Subsection 3.8.5.4 and associated Tier 1 Table 2.1-1 will be revised to incorporate the response for maximum allowable settlement between buildings as indicated on the attached markups.

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.

Table 2.0-1 (3 of 4)

Parameter Description	Parameter Value
Certified Seismic Design Response Spectra (CSDRS) Referencing SSE	See Figures 2.0-1 and 2.0-2
Hard Rock High Frequency (HRHF) Response Spectra(4)	0.46g peak ground acceleration See Figures 2.0-3 and 2.0-4
Fault Displacement Potential (yes/no)	No
Minimum Allowable Static Bearing Demand	718.2 kPa (15 ksf)(3)
Minimum Allowable Dynamic Bearing Demand	2,872.8 kPa (60 ksf)(3)
Minimum Shear Wave Velocity	304.8 m/s (1,000 ft/s)
Liquefaction Potential (	
Maximum Allowable Differential Settlement inside Building	12.7 mm (0.5 in) per 15.24 m (50 ft) in any direction for the Seismic Category I structures
Maximum Allowable Differential Settlement between Buildings	~~12.7 mm (0.5 in)~~ 76.2 mm (3.0 in) between NI Common Basemat and EDG Building & DFOT Building 12.7 mm (0.5 in) between other adjacent buildings
Minimum Soil Angle of Internal Friction	35 degrees
Slope Failure Potential (yes/no)	No
Backfill Material Density	137 pcf
Backfill Material Dynamic Poisson's Ratio	0.33
Backfill Material Dynamic Properties (Minimum Dynamic Shear Modulus, kg/cm^2) - Shear strain	
1 %	0.05
0.1 %	0.22
0.01 %	0.54
0.001 %	0.85
0.0001 %	1.00

Table 2.1-1 (2 of 3)

Tornado	
Maximum Tornado Wind Speed	102.8 m/s (230 mph)
Translational Speed	20.6 m/s (46 mph)
Maximum Rotational Speed	82.2 m/s (184 mph)
Radius of Maximum Rotational Speed	45.7 m (150 feet)
Pressure Drop	8.274 kPa (1.2 psi)
Rate of Pressure Drop	3.447 kPa/s (0.5 psi/s)
Missile Spectra	Table 2 (Region I) of NRC RG 1.76 (2007)
Hurricane	
Maximum 3-Second Wind Gust Speed	116 m/s (260 mph)
Missile Spectra	Table 1 of NRC RG 1.221 (2011)
Soil Properties	
Minimum Allowable Static Bearing Demand	718.2 kPa (15 ksf) (3)
Minimum Allowable Dynamic Bearing Demand	2,872.8 kPa (60 ksf) (3)
Minimum Shear Wave Velocity	304.8 m/s (1,000 ft/sec)
Liquefaction Potential (yes/no)	No
Maximum [Allowable] Differential Settlement inside Building	12.7 mm (0.5 in) per 15.24 m (50 ft) in any direction [for the Seismic Category I structures]
Maximum [Allowable] Differential Settlement between Buildings	~~12.7 mm (0.5 in)~~ [76.2 mm (3.0 in) between NI Common Basemat and EDG Building & DFOT Building 12.7 mm (0.5 in) between other adjacent buildings]
Minimum Soil Angle of Internal Friction	35 degrees
Slope Failure Potential (yes/no)	No
Fault Displacement Potential (yes/no)	No
Backfill Material Density	137 pcf
Backfill Material Dynamic Poisson's Ratio	0.33
Backfill Material Dynamic Properties (Minimum Dynamic Shear Modulus, kg/cm^2) - Shear Strain	
• 1% • 0.1% • 0.01% • 0.001% • 0.0001%	0.05 0.22 0.54 0.85 1.00

The reinforced concrete basemat of the reactor containment building is designed in accordance with ASME Section III, Division 2, Subsection CC. Other seismic Category I basemats of reinforced concrete are designed in accordance with ACI 349 and the provisions of NRC RG 1.142 where applicable.

The design and analysis details for the foundations of safety-related structures are discussed in Subsections 3.8A.1.4.2, 3.8A.2.4.1 and 3.8A.3.4.1.

allowable allowable

The maximum differential settlement of foundation is 12.7 mm per 15.24 m (0.5 in per 50 ft) within NI common basemat. The maximum differential settlement between buildings is ~~12.7 mm (0.5 in)~~ based on enveloping properties of subsurface materials. In addition, the common basemat is analyzed for construction sequences to minimize any potential differential settlement during construction.

provided in Table 2.0-1

3.8.5.4.1 Analyses for Loads during Operation

The reinforced concrete foundations of seismic Category I structures are analyzed and designed for the reactions due to static, seismic and all other significant loads at the base of the superstructures supported by the foundation. The effect of the temperature load in the basemat is negligible and is not considered in the basemat analysis based on ACI 349. According to ACI 349, thermal gradients less than approximately 38 °C (100 °F) need not be analyzed because such gradients do not cause significant stress in the reinforcement or strength deterioration. In the NI common basemat, the temperature gradient is approximately 50 °F and a uniform temperature change is less than 10 °C (50 °F). The analysis of the foundation mat is performed by a three-dimensional finite element structure model, and the forces and moments determined in the analysis are input to the structural design.

The analysis and design of the foundations consider the effects of potential mat uplift, with particular emphasis on differential settlements of the basemat.

The foundation of the seismic Category I structure analysis is performed considering a soil/rock properties beneath the foundation as a nonlinear spring elements. The model is capable of determining the possibility of uplift of the basemat from the subgrade during postulated SSE events. The vertical spring at each node in the analytical model acts in

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.:	**8-7847**
SRP Section:	**02.05.04 – Stability of Subsurface Materials and Foundations**
Application Section:	**2.5.4**
Date of RAI Issued:	**05/14/2015**

Question No. 02.05.04-11

Throughout APR1400 Section 2.5, there are many sentences that provide information on site specific items in the present tense, for example, the first sentence of Section 2.5.4.2 states “The static and dynamic engineering properties of the foundation soil and rock in the site area ***are*** provided”. In reality, such statement should be written in the future tense, as follows “The static and dynamic engineering properties of the foundation soil and rock in the site area ***will be*** provided”. The latter statement is accurate as any site specific work will be performed in the future by any applicant referencing the APR 1400 design. Please propose changes to Section 2.5 where applicable.

Response

Sentences that provide information on site specific items in the present tense will be changed appropriately to the future tense.

Impact on DCD

DCD Section 2.5 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.

2.5 Geology, Seismology, and Geotechnical Engineering

The COL applicant is to provide site-specific information on geology, seismology, and geotechnical engineering as required in NRC RG 1.206 (Reference 1) and described below (COL 2.5(1)). The site-specific information includes the geological, seismological, geophysical, and geotechnical investigation and evaluations procedures to estimate the site-specific ground motion response spectra (GMRS), as well as the geotechnical engineering aspects of the site and slope stability.

2.5.1 Basic Geologic and Seismic Information

Geological, seismological, geophysical, and geotechnical characteristics of the region within 320 km (200 mi) of the site ~~are~~ will be described. The details of the investigations are increased as the radius of the investigation decreases. The site characteristics based on the investigation results ~~are~~ will be described in accordance with NRC RGs 1.206, 1.132, 1.138, and 1.208 (References 1 through 4, respectively).

2.5.2 Vibratory Ground Motion

Information to determine the site-specific GMRS and to compare the GMRS to the seismic design response spectra for the APR1400 ~~is~~ will be described. The design spectra for the APR1400, referred to as the certified seismic design response spectra (CSDRS), are presented in Figures 3.7-1 and 3.7-2.

The APR1400 is evaluated for hard rock high frequency (HRHF) input using the response spectra specified in Subsection 3.7.1. Both the CSDRS and HRHF response spectra are defined at the surface of the finished grade.

2.5.2.1 Seismicity

A complete list of historically reported earthquakes is included in the site-specific data. The list includes earthquakes of Modified Mercalli Intensity (MMI) greater than or equal to IV or a magnitude greater than or equal to 3.0 reported within 320 km (200 mi) of the site. Large earthquakes outside the area that could affect the SSE are included.

2.5.2.2 Geologic and Tectonic Characteristics of the Site and Region

The geologic and seismotectonic characteristics of the region that constitute the basis for defining the seismic source zones that potentially contribute to the seismic hazard at the site ~~are~~ [will be] described. The investigation for seismic sources ~~is~~ [will be] performed for the region within a 320 km (200 mi) radius of the site. Other significant sources beyond this radius ~~are~~ [will be] considered if the sources have the potential to affect the seismic hazard at the site.

2.5.2.3 Correlation of Earthquake Activity with Seismic Sources

The possible correlation between earthquake activity records and the geologic structure and regional tectonic model ~~is~~ [will be] described along with site-specific information. Detailed accounts of the rationale for the association ~~are~~ [will be] provided based on the information regarding the geologic and geophysical data, seismicity, and tectonic history.

2.5.2.4 Probabilistic Seismic Hazard Analysis and Controlling Earthquake

The procedures, technical bases of inputs, and results of the probabilistic seismic hazard analysis (PSHA) ~~are~~ [will be] described. Based on the PSHA results, the seismic hazard curves for the site and uniform hazard response spectra for mean annual frequency of exceedance for 10^{-4}, 10^{-5}, and 10^{-6} ~~are~~ [will be] provided. The controlling earthquakes determined from the deaggregation of seismic hazards ~~are also~~ [will also be] described.

2.5.2.5 Seismic Wave Transmission Characteristics of the Site

The site response analyses using the site-specific geophysical and geotechnical data for each stratum under the site ~~are~~ [will be] described. The data include thickness, compressional and shear wave velocities, bulk densities, soil index properties and classification, shear modulus and damping variations with strain level, and water table elevation and its variations. The method to account for the uncertainty and variation in velocity profiles and site properties ~~is also~~ [will also be] described.

2.5.2.6 Ground Motion Response Spectrum

The site-specific horizontal and vertical GMRS and methodology used to determine the GMRS ~~are~~ [will be] described. For a site with stable surface material, i.e., low-strain shear wave velocity equal to or greater than 304.8 m/s (1,000 ft/s), the GMRS ~~are~~ [will be] determined in the free field on the ground surface. For a site with low-strain shear wave velocity of less

occur. If a site can be classified as uniform, it qualifies for the APR1400 based on analyses and evaluations performed to support design certification without additional site-specific analyses.

2.5.3 Surface Faulting

Detailed surface and subsurface geological, seismological, and geophysical investigations performed around the site ~~are~~ will be compiled on a site-specific basis. Sufficient surface and subsurface information, supported by detailed investigations, either confirms the absence of surface tectonic deformation (i.e., faulting) or, if surface deformation is present, demonstrates the age of its most recent displacement and ages of previous displacements.

The site has no displacement potential by active tectonics.

Structure and generic relationship between site area faulting or other tectonic deformation and the regional tectonic framework ~~are~~ will be described on a site-specific basis. For regions with active tectonics, any detailed geologic and geophysical investigations ~~are~~ will be conducted and described to demonstrate the structural relationships of the site area faults and regional faults known to be seismically active.

2.5.4 Stability of Subsurface Materials and Foundations

Site-specific information ~~is~~ will be presented on the properties of soil and rock formations and their stability under static and dynamic conditions based on evaluations of the site conditions and geologic features that may affect the nuclear power structures or their foundations.

Static properties of subsurface material, such as bearing capacity, settlement, and dynamic properties including liquefaction and soil-structure interaction, ~~are also~~ will also be described.

The foundations for seismic Category I structures of APR1400 can be located on rock and soil.

The acceptability of rock and soil materials for foundations is to be provided to provide reasonable assurance that the assumptions in Subsection 3.7.1 are consistent.

2.5.4.1 Geologic Features

Site-specific geologic features underlying the site, as well as descriptions, maps, and profiles of the site stratigraphy, lithology, structural geology, geologic history, and engineering geology ~~are~~ will be described.

2.5.4.2 Properties of Subsurface Materials

The static and dynamic engineering properties of the foundation soil and rock in the site area ~~are~~ will be provided. Procedures and methods of site investigations follow NRC RG 1.132, "Site Investigations for Foundations of Nuclear Power Plants." Laboratory testing follows NRC RG 1.138, "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants."

Subsurface materials are grouped in terms of origin, geologic stratigraphy, and weathering. The representative values for each group ~~are~~ will be determined.

The site-specific engineering properties include the following:

a. Physical properties (e.g., density, deformation modulus, Poisson's Ratio)

b. Mechanical properties (e.g., strength, bearing capacity)

c. Dynamic properties (e.g., P-wave velocity, S-wave velocity, dynamic deformation modulus, dynamic shear modulus, dynamic Poisson's Ratio)

2.5.4.3 Foundation Interfaces

NRC RG 1.132, "Site Investigation for Foundation of Nuclear Power Plant," defines procedures for and the extent of field investigations to determine the engineering properties of soil and rock materials.

The spacing and minimum depth of sounding as defined in NRC RG 1.132 ~~are~~ will be followed. The results of investigations ~~are~~ will be presented as forms of cross sections and profiles with a proper scale. Piezometers and other monitoring instruments for settlement or tilting, if needed, ~~are~~ will be installed at a proper location to represent the site conditions.

will be

2.5.4.4 Geophysical Surveys

A description ~~is~~ provided of the geophysical investigations performed at the site to determine the dynamic characteristics of the soil or rock, including geophysical methods used to determine foundation conditions. The results of compressional and shear wave velocity surveys and electric resistivity surveys performed to evaluate the occurrence and characteristics of the foundation soils and rocks ~~are~~ provided in tables and profiles.

will be

2.5.4.5 Excavations and Backfill

will be

Site-specific information ~~is~~ provided for excavation and backfill, including properties of borrow and backfill materials, extent (horizontally and vertically) of all seismic Category I excavations, compaction specifications, dewatering, excavation methods, and control measures of groundwater during excavation. Minimum requirements of structural fill granular (SFG) for dynamic properties are described in Table 2.0-1. The typical APR1400 site arrangement is shown in Figure 1.2-1 and the typical profile of basemat and SFG is shown in Figure 2.5-1.

The COL applicant is to confirm that the dynamic properties of SFG to be used in construction of the APR1400 seismic Category I structures satisfy the SFG requirements provided in Table 2.0-1 (COL 2.5(8)).

2.5.4.6 Groundwater Conditions

Basic groundwater conditions are described in Section 2.4. In this subsection, the groundwater conditions relative to foundation stability of the safety-related facilities, plans for dewatering during construction, and plans for analysis of seepage and potential piping conditions during construction ~~are~~ provided. Records of field and laboratory permeability tests and history of groundwater fluctuations ~~are~~ provided.

will be

will be

2.5.4.7 Response of Soil and Rock to Dynamic Loading

Site-specific information ~~is~~ provided on the response of soil and rock to dynamic loading, including investigations to determine the effects of prior earthquakes on the soils and rocks, compressional and shear wave velocity profiles determined from field seismic surveys, and the results of dynamic tests in the laboratory on samples of the soil and rock. The methodology of site response analysis is described in Appendix 3.7A.

will be

2.5.4.8 Liquefaction Potential

As specified in Table 2.0-1, no potential for liquefaction is allowed for seismic Category I structures. The potential liquefaction under non-seismic Category I structures is a site-specific issue to be addressed by combined operating license applicants.

2.5.4.9 Earthquake Site Characteristics

The earthquake site-specific characteristics are described in Subsection 2.5.2.

2.5.4.10 Static Stability

Bearing capacity analysis and settlement computation using stratigraphic conditions, strength, and elastic parameters of the rock mass, building loads, and structural interfaces are provided.

An evaluation of lateral earth pressures and hydrostatic groundwater loads acting on plant facilities ~~is~~ will be provided. Foundation information on seismic Category I structures is provided in Subsection 3.8.5.

An analysis ~~is~~ will be conducted using a two-dimensional or three-dimensional model.

2.5.4.11 Design Criteria

The criteria for the factor of safety (FS) for the safety analysis of foundation rock and slope that may affect seismic Category I facilities are as follows:

Criterion	Factor of Safety
Bearing Capacity	
Ultimate capacity	FS ≥ 3.0
Transient loading	FS ≥ 2.0
Maximum localized stress	FS ≥ 1.2
Slope	
Static condition	FS ≥ 1.5
Dynamic condition	FS ≥ 1.2

The design criteria used in the stability studies of all safety-related facilities, including a description of the computer programs used in the analyses and the soil loads, are provided.

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~~ will be 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~~ will be included in site-specific information.

2.5.6 Combined License Information

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 (Reference 1).

COL 2.5(2) The COL applicant is to confirm that the 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 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).