
REVISED 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.: 252-8299
SRP Section: 03.07.02 – Seismic System Analysis
Application Section: 3.7.2
Date of RAI Issue: 10/19/2015

Question No. 03.07.02-14

10 CFR 50 Appendix S requires that the safety functions of structures, systems, and components (SSCs) must be assured during and after the vibratory ground motion associated with the safe shutdown earthquake (SSE) ground motion through design, testing, or qualification methods. In accordance with 10 CFR 50 Appendix S, the staff reviews the adequacy of the seismic analysis methods used to demonstrate that SSCs can withstand seismic loads and remain functional. Per SRP Section 3.7.2.II.8, to ensure an adequate evaluation of the seismic Category I SSCs in a DC application, it is necessary to determine that they are not vulnerable to collapse or interaction with adjacent non-seismic Category I structures. Consequently, DC applicants should provide sufficient analysis and design information concerning interaction of the non-seismic Category I structures with seismic Category I SSCs for staff review.

DCD Section 3.7.2.7.1, describes three alternate criteria related to providing reasonable assurance that the failure of non-seismic Category I structure under the effect of a seismic event does not impair the integrity of an adjacent seismic Category I structures. Additionally, this DCD section references APR1400-E-S-NR-14005, which contains the details of the structure-soil-structure interaction (SSSI) analysis of the NI structures, EDGB/DFOT, the seismic Category II turbine generator building (TGB), and the seismic Category II compound building (CB). Staff review did not find a clear description of the specific criterion out of the three aforementioned criteria that apply to the evaluation of interaction effects of the TGB and CB with the seismic Category I structures. The staff needs additional information regarding these buildings, to ensure that the NI and EDGB/DFOT are not vulnerable to damage caused by collapse of the TGB or CB. As a minimum, the staff requests the applicant to provide the specific criteria out of the three criteria mentioned above that applies to the TGB and CB; a definition of the seismic input used for the design of these structures, and how the SSSI effects are accounted for in such seismic input; a description of the method of seismic design and analysis applicable to these structures: the maximum relative displacements between these structures and adjacent seismic Category I structures considering out-of-phase motion; and a description of how the potential effects of sliding and uplift have been considered for these structures.

Response - (Rev. 1)

DCD Tier 2, Section 3.7.2.8 (Section number 3.7.2.7.1 has been changed to 3.7.2.8 in the response of RAI 249-8323, Question 03.08.01-16), criterion b which is equivalent to the SRP Section 3.7.2 II.8 criterion C is applied to the turbine generator building and compound building to provide reasonable assurance that failure of the structures under the effects of a seismic event do not impair the integrity of the nuclear island (NI). To describe what criterion is specifically applied to the turbine generator building and compound building, a description will be added in Section 3.7.2.8. In addition, the last phrase of criterion b, "in such a manner that the margins of safety of these structures are equivalent to those of seismic Category I structures," will be removed.

Because the seismic design of the turbine generator building and compound building is outside the scope of the APR1400 standard design, as describe in the response of RAI 252-8299, Question 03.07.02-15, the seismic analyses and design of the turbine generator building and compound building will be performed by the COL applicant. To describe the seismic analysis and structural design approach to be implemented by the COL applicant, DCD Tier 2, Section 3.7.2.8 and the corresponding COL information item (COL 3.7(4)) in Section 3.7.5 will be revised.

The COL applicant is to check and consider the potential effects of sliding and uplift for the turbine generator building and compound building using the same approach that is used in the stability check for the NI common basemat, as described in APR1400-E-S-NR-14006-P. The DCD Tier 2, Section 3.7.2.8 and the corresponding COL information item (COL 3.7(4)) in Section 3.7.5 will be revised.

Impact on DCD

DCD Tier 2, Subsections 3.7.2.8, 3.7.5, and Table 3.2-1 will be revised, as indicated in the attachment associated with this response.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

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

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$$R_{rI} = \sum_{i=1}^n R_{ri} + R_{missmassI}$$

where $R_{missmassI}$ is the residual rigid response of the missing mass modes for the I_{th} component of seismic input motion. The effect of missing mass modes not included in the analysis is accounted for by using the method given in NRC RG 1.92.

Finally, the combined response is calculated as follows:

$$R_I = [R_{rI}^2 + R_{pI}^2]^{1/2}$$

3.7.2.8

RAI 249-8323 - Question 03.08.01-16

3.7.2.7.1 Interaction of Non-Seismic Category I Structures with Seismic Category I Structures

The interfaces between seismic Category I and non-seismic Category I structures are designed for the dynamic loads and displacements produced by both the seismic Category I and non-seismic Category I structures.

To provide reasonable assurance that the failure of a non-seismic Category I structure under the effect of a seismic event does not impair the integrity of an adjacent seismic Category I structure, one of the following ~~procedures~~ is used:

criteria

- Maintenance of sufficient separation between non-seismic Category I structures and seismic Category I structures
- Analysis and design of non-seismic Category I structures to prevent their failure under SSE conditions ~~in such a manner that the margins of safety of these structures are equivalent to those of seismic Category I structures~~
- Design of seismic Category I structures to withstand loads due to the collapse of the adjacent non-seismic Category I structures if sufficient spatial separation is not achieved

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The seismic Category II turbine generator building and compound building are analyzed and designed to prevent their failure under SSE conditions (criterion b). Since the seismic Category II alternate alternating current gas turbine generator building is located at a considerable distance from the seismic Category I structures, as shown in Figure 1.2-1, criterion a is applies to the alternate alternating current gas turbine generator building.

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The turbine generator building and compound building are ~~classified as non seismic Category I structures and are~~ located on the west side and south side of nuclear island with a ~~1.0 m~~ (3 ft) gap on each side. Figures 3.7-40 and 3.7-41 show the FEMs of the turbine generator building and compound building, respectively. To evaluate the structure-soil-structure interaction effects on the nuclear island structures due to presence of adjacent non-seismic Category I structures, the structure-soil-structure interaction analysis using the coupled model for entire structures is performed. The interaction effects of these non-seismic Category I structures on the nuclear island are negligible as provided in Technical Report, APR1400-E-S-NR-14005-P (Reference 20).

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~~The COL applicant is to confirm that the any site-specific non-seismic Category I SSCs are designed not to degrade the function of a seismic Category I SSC to an unacceptable safety level due to their structural failure or interaction (COL 3.7(4)).~~

3.7.2.8 Effects of Parameter Variations on Floor Response Spectra

To consider variations in the structural frequencies due to the uncertainties in material properties of the structure and approximations in modeling, the peaks of the computed floor response spectra are broadened by ± 15 percent and smoothed in accordance with NRC RG 1.122, as described in Subsection 3.7.2.5.

The effects of potential concrete cracking on the structural stiffness of reinforced concrete structures are considered as enveloping the floor response spectra for cracked concrete properties with 7 percent damping for the reinforced concrete structures and those for uncracked properties with 4 percent damping for the reinforced concrete structures.

Both uncracked and cracked concrete stiffnesses are considered separately in the seismic analysis models of the seismic Category I structures. For consideration of potential concrete cracking, the cracked concrete stiffness in horizontal and vertical seismic analysis models is reduced by half of the uncracked concrete stiffness except prestressed concrete containment structure and reinforced concrete columns and walls in the vertical models described in ASCE/SEI 43-05 (Reference 21). Therefore, for nine soil profiles and one fixed-base condition, a total of 20 analysis cases are performed in the seismic analysis to generate the floor response spectra of the seismic Category I structures.

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The COL applicant is to confirm that any site-specific non-seismic Category I structures are designed not to degrade the function of a seismic Category I SSC to an unacceptable safety level due to their structural failure or interaction. The relative displacements calculated by the COL applicant are not to exceed the gaps between seismic Category I and non-seismic Category I structures.

For the seismic analysis of the seismic Category II structures, the site-specific FIRS are applied as seismic input motions and a site-specific soil profile is to be established as a supporting media. The same seismic analysis procedure which is applied to the seismic Category I structures is also applied to the seismic Category II structures.

The design codes used by the COL applicant for the structural design of the seismic Category II structures are as follows:

- a. The design of the turbine generator building is performed using ACI 318 or AISC 360 as described in Table 3.2-1.
- b. The compound building is designed according to RW-IIa criteria in RG 1.143. Hence, the design of the compound is performed using ACI 349 or AISC N690 as described in Table 3.2-1.
- c. The design of the alternate alternating current gas turbine generator building located on the southwest side of the plant is performed using ACI 318 as described in Table 3.2-1.

The potential effects of sliding and uplift for the seismic Category II structures are checked using the same approach applied in the stability check for the seismic Category I structures (COL 3.7(4)).

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- 2) The pre-shutdown inspection procedure supports determination of the effects of the earthquake on essential safe shutdown equipment. Following the earthquake, the equipment must be inspected for any needed resets or repairs, as well as for readiness prior to initiating shutdown activities.
- 3) The post-event inspection procedure supports determination of the degree of damage to equipment and equipment acceptability for continued operation.

3.7.5 Combined License Information

COL 3.7(1) The COL applicant is to determine the site-specific SSE and OBE that are applied to the seismic design of the site-specific seismic Category I and II SSCs and the basis for the plant shutdown. The COL applicant is also to verify the appropriateness of the site-specific SSE and OBE.

COL 3.7(2) The COL applicant is to confirm that the horizontal components of the site-specific SSE ground motion in the free-field at the foundation level of the structure satisfy a peak ground acceleration of at least 0.1g.

~~COL 3.7(3) The COL applicant is to provide the seismic design of the seismic Category I SSCs that are not part of the APR1400 standard plant design. The seismic Category I structures are as follows:~~

- ~~a. Seismic Category I essential service water building~~
- ~~b. Seismic Category I component cooling water heat exchanger building~~

~~COL 3.7(4) The COL applicant is to confirm that the any site-specific non-seismic Category I SSCs are designed not to degrade the function of a seismic Category I SSC to an unacceptable safety level due to their structural failure or interaction.~~

COL 3.7(5) The COL applicant is to perform any site-specific seismic design for dams that is required.

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COL 3.7(3) The COL applicant is to provide the seismic design of the seismic Category I SSCs and seismic Category II structures that are not part of the APR1400 standard plant design. The seismic Category I and II structures are as follows:

- a. Seismic Category I essential service water building
- b. Seismic Category I component cooling water heat exchanger building
- c. Seismic Category II turbine generator building
- d. Seismic Category II compound building
- e. Seismic Category II alternate alternating current gas turbine generator building

COL 3.7(4) The COL applicant is to confirm that any site-specific non-seismic Category I structures are designed not to degrade the function of a seismic Category I SSC to an unacceptable safety level due to their structural failure or interaction. The COL applicant is to confirm that the calculated relative displacements do not exceed the gaps between seismic Category I and non-seismic Category I structures. The COL applicant is to apply the site-specific FIRS as seismic input motions and to establish a site-specific soil profile as a supporting media for the seismic analysis of the seismic Category II structures. The COL applicant is to apply the same seismic analysis procedure as the seismic Category I structures to the seismic Category II structures. The COL applicant is to perform the structural design of the seismic Category II structures using the design codes described in Subsection 3.7.2.8 and Table 3.2-1. The COL applicant is to check the potential effects of sliding and uplift for the seismic Category II structures using the same approach applied in the stability check for the seismic Category I structures.

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Table 3.2-1 (1 of 86)

Classification of Structures, Systems, and Components⁽¹⁾

Item No. / Principal SSCs	Location ⁽²⁾	Safety Class	Quality Group	Codes and Standards	10 CFR 50, App. B ⁽³⁾	Seismic Category	Remarks
I. Major Structures							
1. Containment Building (including mechanical and electrical penetrations)		SC-2	B	ASME Sec. III NE-2007 with 2008 addenda, ASME Sec. III CC-2001 with 2003 Addenda	Yes	I	
2. Containment Building Internal Structures (including radiation shield)		SC-3	N/A	ACI 349-1997, ANSI/AISC N690-1994 incl. Supp. 2 (2004)	Yes	I	
3. Auxiliary Building (including TSC)		SC-3	N/A	ACI 349-1997, ANSI/AISC N690-1994 incl. Supp. 2 (2004)	Yes	I	(4)
4. Turbine Generator Building		NNS	N/A	ACI 318-2008 AISC 360-2005	A	II	(3)(d)
5. Compound Building		NNS	N/A	ACI 318-2008 AISC 360-2005	A	II	(3)(d), (4)
6. Emergency Diesel Generator Building		SC-3	N/A	ACI 349-1997, ANSI/AISC N690-1994 incl. Supp. 2 (2004)	Yes	I	
7. Alternate AC Generator Building		NNS	N/A	ACI 318-2008	A	II	(3)(d)
8. Essential Service Water Building		SC-3	N/A	ACI 349-1997, ANSI/AISC N690-1994 incl. supp. 2(2004)	Yes	I	

Alternate Alternating Current Gas
Turbine Generator Building

ACI 349-1997, ANSI/
AISC N690-1994 incl.
Supp. 2 (2004)

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Table 3.2-1 (85 of 86)

- (4) Designed in accordance with NRC RG 1.143. The radwaste facilities, including the structures, systems, and components, are designed to meet the design basis loads, including the natural phenomena and internal and/or external man-induced hazards design criteria, in accordance with NRC RG 1.143.
- The radwaste safety classifications for the radioactive waste management systems: LWMS, GWMS, SWMS, and the SGBD systems and components, are presented in Sections 11.2, 11.3, 11.4, and 10.4.8, respectively.
 - The radwaste safety classification for the compound building, in which the LWMS, GWMS, and SWMS are housed, is RW-IIa in accordance with the guidance in RG 1.143. ~~Radwaste treatment structure classified as Class RW-IIa is designed and constructed to meet the requirements of ACI 349 and AISC N690.~~
 - The components for the SGBD system are housed in the auxiliary building. The seismic design requirements for the auxiliary building exceed those for the radwaste safety classification. The seismic design loads for the building housing the SGBD system shall follow those for the auxiliary building.
- (5) Designed based on guidance contained in NRC NUREG-0696 and NUREG-0737, Supplement 1.
- (6) Security system requirements per 10 CFR 73.
- (7) IEEE 497 endorsed by NRC RG 1.97 post-accident monitoring parameters. Instrumentation meets qualification and quality requirements of this NRC RG and IEEE 497.
- (8) Guidance per NUREG-0718 and NRC RG 1.47.
- (9) Earthquake monitoring is per NRC RG 1.12.
- (10) Design guidance per NRC RG 1.13.
- (11) Design guidance per NRC RG 1.13, NUREG-0554, and NUREG-0612.
- (12) Design guidance per NRC RG 1.189.
- (13) The entire crane, including the bridge and trolley, is designed and constructed in accordance with NRC RG 1.29.
- (14) Non-safety-related diverse protection system per 10 CFR 50.62 and GL 85-06.
- (15) Non-safety-related ACUs and components, including fan/motor and associated isolation dampers, are designed and constructed per NRC RG 1.140.
- (16) Design guidance per NRC RG 1.45.
- (17) These codes and standards are applied to requirements of interface design.

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