Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 17-18, 2012

Seismic Design Parameters of the APR1400 DC

Jang Jung-Bum[a*], Yun Kwan-Hee[a], Oh Seung-Jong[b]
[a]*KEPCO RI, 103-16, Munji-dong, Yuseong-gu, Daejeon, 305-380*
[b]*KINGS, 1456-1, Shinam-ri, Seosaeng-myeon, Ulju-gun, Ulsan, 689-882*
[*]*Corresponding author: jbjang@kepco.co.kr*

1. Introduction

The APR1400 DC project to acquire a design certification (DC) from US NRC is being proceeded for the foreign export of Korean nuclear power plants. To acquire a design certification from US NRC, many seismic regulatory requirements which are revised recently, should be reflected into design of the APR1400 DC. However, the latest seismic regulatory requirements have a large impact on the design of the APR1400 DC and the seismic design parameters have to be selected carefully.

We have minimized the trial and error found in the process of seismic analysis by selecting seismic design parameters in consistent with regulatory requirements of US NRC such as Regulatory Guides, NUREG-0800, ISG, and Generic Letter etc. In addition, the request for additional information (RAI) issued from AP1000, US-APWR, and US EPR currently under review of US NRC, are considered. In the end, we intend to prevent the delay of schedule due to the seismic re-design of the APR1400 DC.

To successfully complete APR1400 DC project with the above considerations, the selected seismic design parameters are presented in this paper.

2. Seismic Design Parameters

The APR1400 DC design response spectrum, now referred to as the Certified Seismic Design Response Spectra (CSDRS), is provided in Fig. 1 for the horizontal components with 5 % damping.

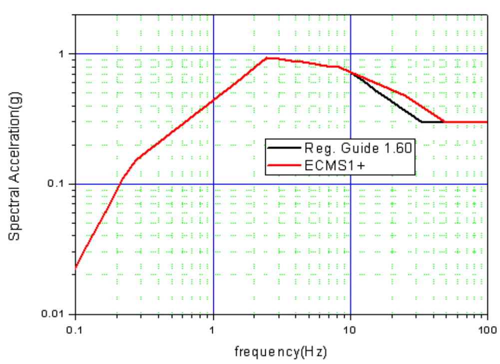

Fig. 1. CSDRS for APR1400 DC

The CSDRS of the APR1400 DC is based on the Regulatory Guide 1.60 but the spectral acceleration increases by 30 % at 25 Hz and the design response spectrum slopes down from 25 Hz to 50 Hz to enhance the high frequency contents. The peak ground acceleration of the safe shutdown earthquake has been established as 0.3g.

The design response spectra are applied at the foundation level in the free field at hard rock sites and at the finished grade in the free field at the other soil sites.

According to the standard review plan (SRP) 3.7.1, the CSDRS design ground motion time histories can be either real time histories or artificial time histories. Also, artificial time histories which are not based on seed recorded time histories should not be used. Therefore, artificial time histories are adopted for design time histories of the APR1400 DC and the Northridge earthquake is used as seed recorded time histories. The Northridge earthquake was an earthquake that occurred on January 17, 1994 and had a strong moment magnitude of 6.7.

The APR1400 DC nuclear island consists of three seismic category I structures founded on a common basemat. The three structures that make up the nuclear island are the reactor containment building, the containment internal structures, and the auxiliary building. For the design of seismic category I structures, a set of 10 design soil profiles (that include hard rock) of various shear wave velocities is established as a draft. Summarized in Table 1 is the set of nine soil profiles (excluding hard rock) for supporting media of the APR1400 DC

Table 1. Soil profiles for APR1400 DC (Draft)

Layer Site Category / Depth from Ground Surface (ft)	Generic Soil Profile No.								
	1	2	3	4	5	6	7	8	9
	Average-Shear-Wave-Velocity No. (Shown in Table below)								
A 0 ~ 50 ft	1	1	2	2	3	2	2	4	4
B 50 ~ 100 ft	1	1	2	2	3	3	3	4	4
C 100 ~ 200 ft	1	2	2	3	4	3	4	4	5
D 200 ~ 500 ft	2	3	3	4	4	5	5	5	5
E 500 ~ 1,000 ft	3	4	5	5	5	5	5	5	5
F > 1,000 ft	5	5	5	5	5	5	5	5	5

The average-shear-wave-velocity-profile categories 1 through 5 are described in Table 2.

Most existing nuclear plants in the central and eastern U.S. (CEUS) have been designed to earlier, deterministic response spectra in accordance with Regulatory Guide 1.60 that have dominant energy content in the frequency range of 2 to 10 Hz. The more recent site-specific probabilistic hazard-based ground motion response spectra for new plants in the CEUS have high frequency spectral content (greater than 10 Hz range) which exceeds design spectra scaled from Regulatory Guide 1.60 spectra shapes. Therefore, ground motion response spectrum (GMRS), showing higher amplitude at high frequency than the CSDRS in the CEUS rock sites, is considered in the design of APR1400 DC. The site-specific seismic hazards at 60 CEUS sites using up-to-date models for seismic sources and ground motion equations were calculated and seismic hazard results were presented in the form of GMRS. Fig. 2 presents the spectral plot for the design of APR1400 DC, which shows the median and other fractiles of GMRS spectra for all 60 sites assuming hard rock conditions at each site. High frequency seismic input will be used in the evaluation to confirm that it is not damaging to equipment and structures qualified by analysis for the CSDRS of the APR1400 DC. Also, the incoherency analysis will be applied to reduce the response of building foundation to the high frequency portion of this seismic input.

Table 2. Average-shear-wave-velocity category vs velocity

Average-Shear-wave-velocity Category	Average-Shear-Wave-Velocity (ft/sec)
1	1,200
2	2,000
3	4,000
4	6,000
5	9,200

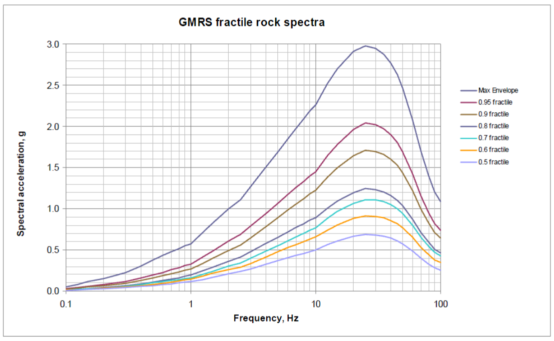

Fig. 2. GMRS fractile rock spectra

According to DC/COL-ISG-01, structural models are adequately refined to sufficiently capture the high frequency content of the horizontal and vertical ground motion response spectrum in the structural response. In addition, the range of high frequency to be transmitted should cover a model refinement frequency of at least equal to 50 Hz. Also, the GMRS for CEUS rock sites show higher amplitude at high frequency than the CSDRS. Therefore, based on the general plant arrangement, three-dimensional, finite element models are developed for the nuclear island structures to adequately identify the global response and local mode in high frequency range. These three-dimensional, finite element models provide the basis for the development of the dynamic model of the nuclear island structures as shown in Fig. 3.

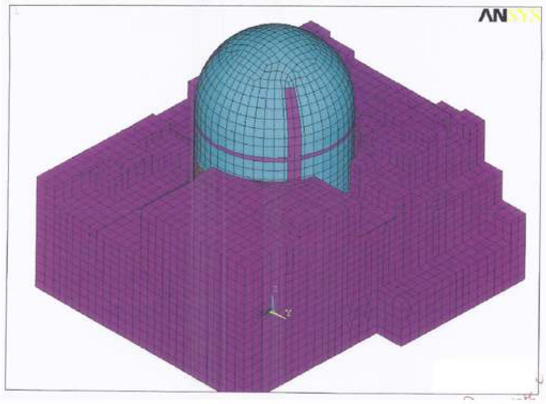

Fig. 3. The three dimensional finite element model

The effect of potential concrete cracking on floor response spectrum will also be addressed for concrete structures and it will be analyzed as embedded structures.

3. Conclusions

The APR1400 DC project to acquire a design certification (DC) from US NRC is being proceeded for the foreign export of Korean nuclear power plants. To acquire a design certification from US NRC, many seismic regulatory requirements which are revised recently, are reflected into design of the APR1400 DC. We have minimized the trial and error found in the process of seismic analysis by selecting seismic design parameters coincided with regulatory requirements of US NRC and considering the RAIs issued from new reactors currently under review of US NRC. To successfully complete APR1400 DC project, new seismic design parameters are selected and seismic analysis is currently being carried out. New seismic design parameters and analysis methodologies considered in the APR1400 DC will contribute to the technological advancement of seismic field.

REFERENCES

[1] US NRC, Standard Review Plan 3.7.1 Seismic Design Parameters, NUREG-0800, 2007.
[2] US NRC, Standard Review Plan 3.7.2 Seismic System Analysis, NUREG-0800, 2007.
[3] US NRC, Interim Staff Guidance on Seismic Issues Associated with High Frequency Ground Motion in Design Certification and Combined License Applications, 2007.
[4] US NRC, Interim Staff Guidance on Ensuring Hazard-Consistent Seismic Input for Site Response and Soil Structure Interaction Analyses, 2009.
[5] US NRC, Regulatory Guide 1.60, Design Response Spectra for Seismic Design of Nuclear Power Plants, 1973.