APR+ Design Features in Preparation for External Hazards

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1. Introduction

Since initial commercial operation in 1978, 21 Nuclear Power Plants (NPPs) have been operated with high operability rate in Korea. Based on the experiences with the construction and operation in the domestic nuclear power plants, the Advanced Power Reactor 1400 (APR1400) was developed and its construction has been under way. As a successive reactor of APR1400, the APR+ has been being developed, and the related licensing review is in progress.

2. Earthquake Protection

For the protection from the strong earthquake, structure, piping and components of the APR+ are designed to satisfy site envelope seismic requirements. These requirements are determined through the reviews on the site-specific conditions of the domestic and foreign competitive reactors such as AP1000, US-EPR, US-APWR. As shown in figure 1, seismic design response spectrum over the high frequency range is expanded by enveloping cut-off frequency 33Hz to 50Hz and increasing 130% at the range of around 25Hz input motion which is Safe-Shutdown Earthquake (SSE) maximum ground acceleration of not less than 0.3g.

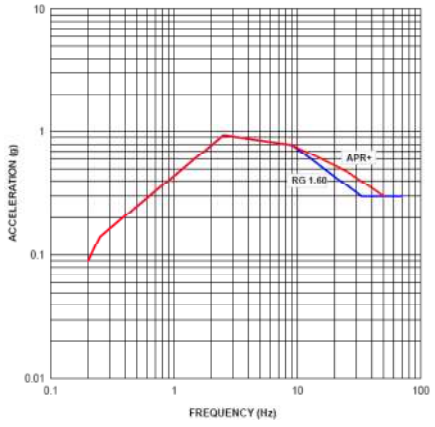

Fig. 1 The comparison of APR+ seismic design response spectrum with RG 1.60

The Nuclear Island (Containment Building, Auxiliary Building) structures share one common basemat which is 10 ft thick and rectangular type. The auxiliary building is composed of Steel-plate Concrete (SC) outer walls with a seismic gap of 2 inches. And for the soil-structure interaction analysis of lumped-mass stick models with computational model as shown in figure 2, the methodology of the computer program SASSI is used.

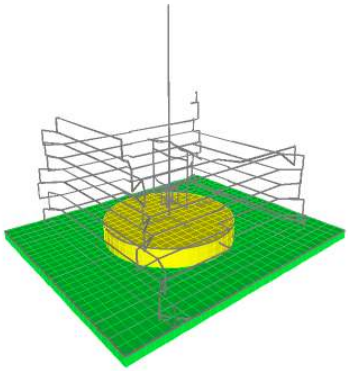

Fig. 2 The computational model for seismic analysis of APR+

In addition, the automatic seismic trip system (ASTS) preparing for the strong earthquake is added. The ASTS will be acted automatically at a certain level of earthquake prior to SSE.

3. Fire Protection

In preparation for fire, each room in the Auxiliary Building (AB) that has many safety related components is designed to be separated by 3 hour fire resistance barrier as well as equipped with fire suppression system. And, according as most of safety related components with same function such as 4 train electrical and mechanical systems, are arranged along the quadrant utilizing the AB structure wrapped around the Reactor Containment Building (RCB) as shown in figure 3, even in case of fire, safe shutdown capability is largely enhanced.

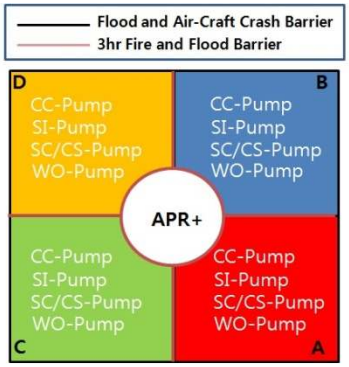

Fig. 3 Quadrant arrangement of the AB

For the internal fire protection of the RCB, the number of Passive Auto-catalytic Recombiners (PAR) is significantly increased compared with that of operating NPPs to mitigate the hydrogen concentration even in the station blackout.

And, in preparation for the depletion of fire water source in power block, alternative water source connected with the fire truck will be provided.

4. Flood Protection

For internal flood protection, possible flood sources in power block are minimized in APR+ design. That is, the arrangement of water systems is made considering the flooding damage when each water system is assumed as a single possible flood source. In detail, the essential service water system (ESWS) is located outside the auxiliary building to eliminate a significant source of water. The component cooling water system (CCWS) and passive auxiliary feedwater systems (PAFS) are fully separated by quadrant, thus eliminating the possibility of a single flood source within these systems impacting both divisions. In case of malfunction of emergency power supply system due to the flooding, a truck equipped with an emergency generator and a storage battery are utilized as temporary power.

The flood protection measures for Seismic Category I structures, systems and components (SSCs) are provided in accordance with Regulatory Guide 1.102, "Flood Protection for Nuclear Power Plants." In that respect, the water tight doors are installed on the exits in the ground floor of AB and Emergency Diesel Generator (EDG) building. For the other openings, their levels are adjusted upward or the design for the flooding protection is applied. Flood protection is also integrated into the floor drainage systems. Floors are gently sloping to allow good drainage to the quadrant sump. Floor drains are directed to the lowest elevation to prevent floods in the upper elevations. The lower elevation in each quadrant has sufficient volume to gather water from a leak in any system without flooding the other quadrant.

For external flooding as a result of secondary flooding sources located in the turbine building, entrances to the AB from the turbine building are elevated above plant grade to prevent flood propagation.

5. Aircraft Crash Protection

The design criteria considering the aircraft crash was included in the regulation for new nuclear power plants, which have applied the certification to Nuclear Regulatory Commission (NRC), since July in 2009. To meet the criteria, the exterior wall thickness of the RCB containing safety-related equipment is added to 0.5 ft. The wall thickness of AB is increased by 1 ft as well. Furthermore, the blast dampers are expected to be installed at the openings for preventing propagation of flame caused by aircraft crash. And the MCR is protected by locating its level down to the 2nd floors in four-story AB so that MCR is way off the target position of aircraft. EDG buildings are physically separated to provide protection from the aircraft crash.

The structural design features of APR+ for aircraft crash are presented in table 1. The several features have been determined by the analyses based on the foreign design requirements, test and analysis results, and industrial design experience. In other words, APR+ has the structural integrity as equals or superior to the competitive foreign reactors. Licensing review on the evaluation result of structural integrity and vibration analysis for the reinforcing design is in progress currently.

Table 1. Structural design features for aircraft crash

Plant model	APR+	
	Wall Thickness	Evaluation Airplane
Reactor Building	4~4.5ft	-Boeing 767-400
Auxiliary Building	5ft	

6. Conclusions

APR+ has been developed to withstand various site environments including strong earthquake in comparison to the operating NPPs. And seismic design of major components is enhanced by expanding further the high frequency regime so that the design of APR+ is considered to meet recently enhanced international regulatory. In preparation for an unexpected fire, safety-related components are located separately within quadrant of AB which has a wrapped-around structure. The protection ability against the external hazards is advanced in a way that the structures are considerably reinforced against the flood and aircraft crash.

After standard design approval, the completion of Shin-Kori 7 and 8 aimed for 2022 will be planned.

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