Floor Response Spectrum Analysis at Different Location of the Same Equipment in the Auxiliary Building of NPP Using 3D FE Model

Hyung-Kui Park [a*], Junhee, Park [a], In-Kil Choi [a]
[a] Korea Atomic Energy Research Institute, 989-111 Deadeok-daero, Deajeon,305-353, Republic of Korea
[*]*Corresponding author: hyungkui@kaeri.re.kr*

1. Introduction

Since the auxiliary building of nuclear power plant is a very complex structure, an evaluation of seismic response has been conducted by using a simplified beam-stick model. However, the simplified model cannot confirm the response inside the structure. In the auxiliary building, there are a number of the same equipment. In conventional probability safety assessments of nuclear power plant, the probability of failure is assumed to be the same without taking into account the correlation coefficient for the same equipment. Even if the same equipment is installed in a symmetrical position, since the auxiliary building is not a completely symmetrical structure, the seismic load transmitted to the equipment is inevitably different.

In this study, a more realistic seismic response was considered based on three-dimensional finite element analysis. The correlation between the same equipment due to the seismic load was studied by analyzing the FRS for different locations of the same equipment.

2. Three-dimensional Finite Element Model

The finite element analysis was performed for the auxiliary building of the nuclear power plant. The seismic response was evaluated by generating artificial seismic accelerations based on the target spectrum.

2.1 Auxiliary Building Model

The auxiliary building consists of three stories. The numerical model consists of 121114 shell elements (S4R). The reinforcing bars were modeled using layered shell elements. The bottom side of the building was assumed to be fixed and seismic loads were applied in EW direction. The FE model of auxiliary building is shown in figure 1.

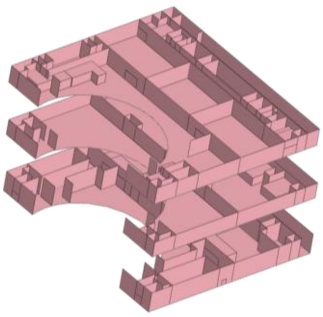

Fig. 1. The 3D FE model of auxiliary building

To verify the developed analysis model, eigenvalue analysis was performed and compared with the results of the existing model of beam-stick.

The analysis results are summarized in Table I, and it was confirmed that the developed model was similar to the beam-stick model.

Table I: Results of eigenvalue analysis

	Beam-Stick	3D FEM	Direction
1st mode frequency	7.22	7.22	EW
2nd mode frequency	7.65	7.77	NS

The time-acceleration of the seismic load was applied on EW direction using the base-motion option.

2.2 Material Model

The material model is assumed to be linear. The material properties used in the analysis are summarized in Table II.

Table II: The material properties

	Concrete	Reinforcing bar
Elastic Modulus (psi)	4,031,000	29,000,000
Poisson's Ratio	0.17	0.3

2.3 Artificial Seismic Acceleration

The artificial seismic accelerations were generated using the p-cares. The input accelerations were generated with a time interval of 0.005 second and a total of 40.96 second. The target spectrum (UHS) is shown in figure 2.

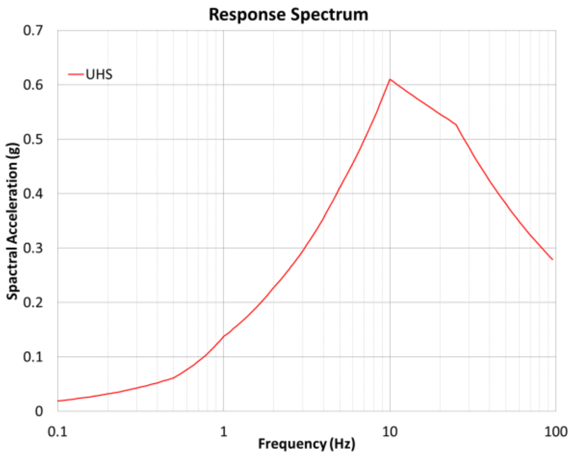

Fig. 2. The target spectrum (UHS)

The peak ground acceleration (PGA) of the seismic load is 0.273g. The time-acceleration generated by using the p-cares is shown in figure 3.

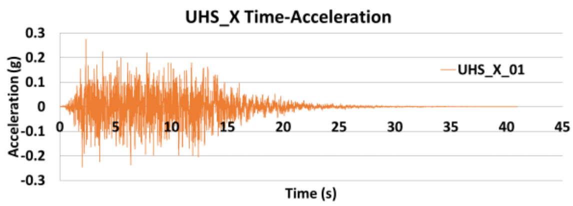

Fig. 3. The time-acceleration of EW direction

2.4 Locations of Seismic Response

Based on the different locations of same equipment (battery & racks), the points of the auxiliary building was selected. As shown in figure 4, the selected points of the auxiliary building for analysis of floor response spectrum.

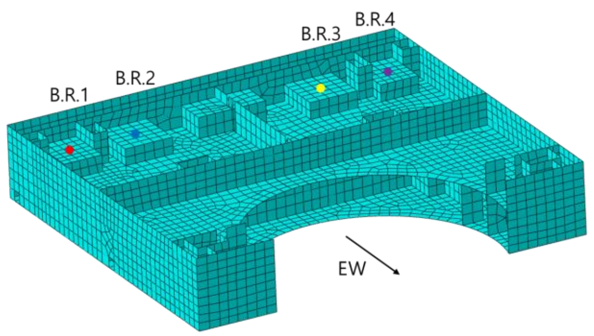

Fig. 4. The selected point of the auxiliary building

3. Analysis Result

Figure 5 shows the comparison of FRS for the each locations.

Overall, the results showed similar patterns, but it could be confirmed that the results were not the same at the four locations. In particular, the results were very similar in the symmetrical position in the EW direction.

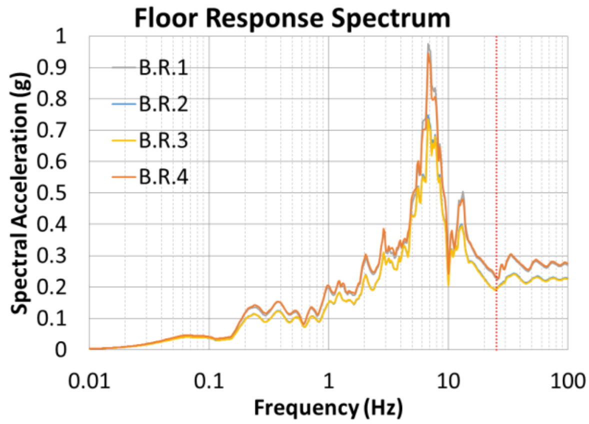

Fig. 5. The comparison of FRS (EW direction) for the each locations.

Table III summarizes spectral acceleration in the natural frequency of the battery & rack (25.3Hz), and the difference ratio is summarized based on B.R.3, which has the lowest value.

Table III: The difference ratio of S.A base on the natural frequency of the battery & rack

	B.R.1	B.R.2	B.R.3	B.R.4
S.A (g)	0.2289	0.1936	0.1916	0.2345
Ratio (%)	19.468	1.044	0	22.390

The largest response difference occurred between B.R.3 and B.R.4, which are non-symmetrical positions. Although it is the same equipment, it was confirmed that the response difference of up to about 22.4% occurred depending on the location. Since the auxiliary building is not a perfectly symmetrical structure, it is judged that a difference in response occurs.

The difference in response by position cannot be confirmed in the simplified beam-stick model. The difference in response from the same equipment is expected to affect the PSA, and for the more realistic evaluation of safety, FRS at detailed location should be considered.

4. Conclusions

In this study, the FRS for the detailed location of the auxiliary building modeled using 3D FEM was analyzed. The 8-story auxiliary building was simplified into 3-story modeled, and the analysis model was verified by comparing the results of the existing beam-stick model.

The analysis target locations are the other four locations where the battery rack is located. In the symmetrical position, very similar responses were shown, but if not, a maximum difference of 22.4% occurred.

In some cases, these differences in responses can be underestimated of the safety assessments.

Therefore, for a more realistic the safety assessments, it is judged that the FRS response for each detailed location should be considered.

Acknowledgement

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