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Floor Response Spectrum Analysis of Auxiliary Buildings of Nuclear Power Plant Using 3D FE Model

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1. Introduction

A lot of research to ensure nuclear plant safety against seismic loads has been carried out. The Nuclear Regulatory Commission (NRC) provides the design guides [1] that make sure that nuclear plants are built to withstand seismic loads. The target spectrum is devised in line with the characteristics of the plant site. Therefore, the target spectrum should reflect the characteristics of the site where the nuclear power plant is located.

Since the nuclear power plant is a very complex structure to model in detail, a seismic response evaluation has been conducted by using a simple beam-stick model. However, such simplified model is not appropriate to investigate the internal response of the structure.

In this study, a more realistic seismic response was considered based on three-dimensional finite element analysis. The floor response spectrums from the two target spectrums, REG 1.60 and UHS were compared and analyzed.

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 six stories. The numerical model consists of 17233 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.

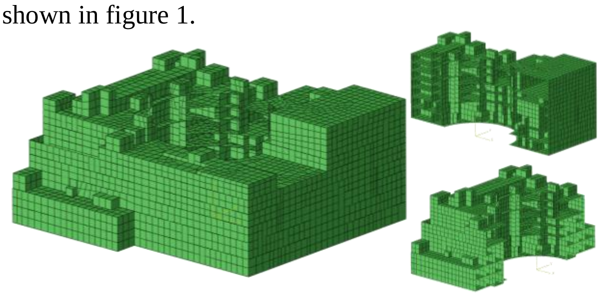

Fig. 1. The FE model of auxiliary building

The time-acceleration of the seismic load was applied 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 1.

Table I: The material properties

	Concrete	Reinforcing bar	Steel
Elastic Modulus (psi)	4,031,000	29,000,000	29,008,000
Poisson Ratio	0.17	0.3	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 compared target spectrum is shown in figure 2.

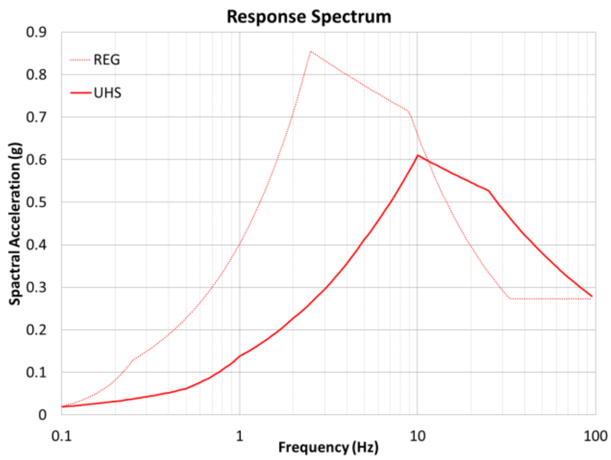

Fig. 2. The two target spectrum, REG 1.60 and UHS

Compared with the design spectrum from REG 1.60, it shows that uhs has more high frequency component.

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

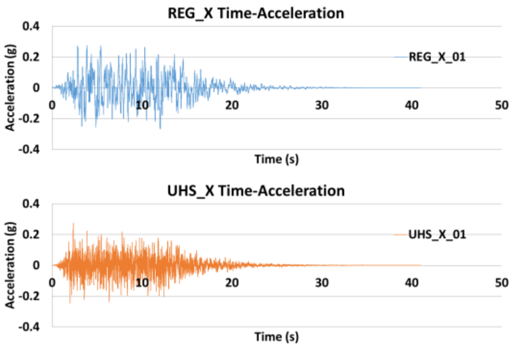

Fig. 3. The time-acceleration generated by using the p-cares

The time-acceleration generated based on UHS has much higher frequency components than the one from REG 1.60.

2.4 Locations of Seismic Response

Based on the analysis of the pushover analysis, the weak area of the auxiliary building was selected. The floor response spectrum for each floor from the 2nd-floor to the building roof were derived. The 1st-floor is excluded from the analysis because it has the same result as the input time-acceleration due to the base-motion option. As shown in figure 4, the selected weak area of the auxiliary building for floor response spectrum analysis.

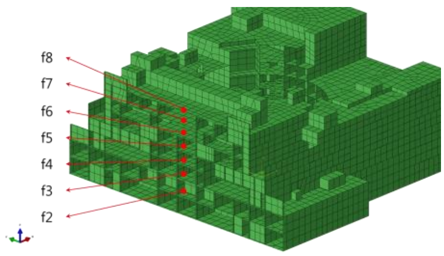

Fig. 4. The selected weak area of the auxiliary building

3. Analysis Result

As shown in figure 5, the floor response spectrums from REG 1.60 are compared with the spectrums from UHS. As shown in figure 6 below, the analyzed floor response spectrum from the 7th-floor.

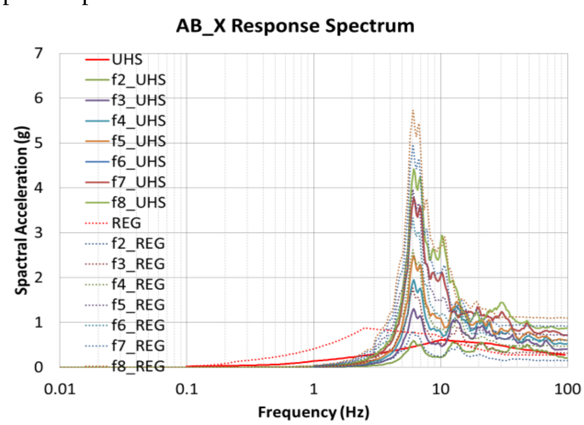

Fig. 5. The floor response spectrum of the auxiliary building

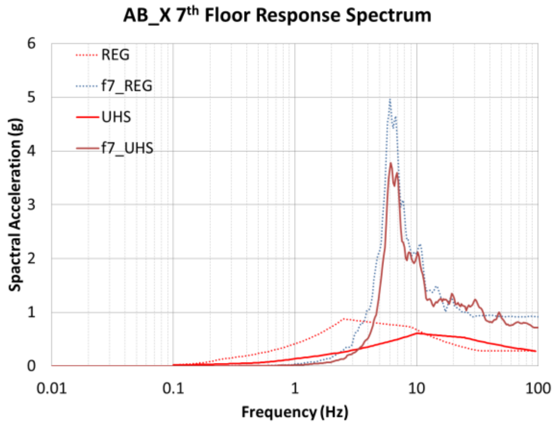

Fig. 6. The analyzed floor response spectrum from the 7th-floor

The dotted line is the result from REG 1.60 and the solid line from UHS. It can be seen that the maximum response for each floor occurs at the first mode frequency of the auxiliary building. It can be confirmed that the response to the high frequency component of the UHS is large due to the influence of the input component. For the same reason, REG 1.60 shows a large response to the low frequency compared with UHS. It is also confirmed the characteristic that the floor response spectrum rises increasingly on the upper floors.

4. Conclusions

In this study, the seismic response analysis of the auxiliary building was performed by employing a three - dimensional finite element model. By using the three-dimensional model, it was possible to obtain a response at a more realistic position. The response changes due to the divergences between input components were analyzed. With more high frequency being observed in UHS than REG, it could be disadvantageous when it comes to evaluate the safety assessment of target devices. Therefore, using the response spectrum of a target site is required for more accurate safety assessments.

Acknowledgement

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REFERENCES

[1] US Nuclear Regulatory Commission Regulatory Guide 1.60 (2014), "Design response spectra for seismic design of nuclear power plants"
[2] SIMULIA, ABAQUS Version 6.14 Analysis User's Manuals, 2014.