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Assessment of spatial variation of seismic waves through analysis of earthquake records at Hamaoka Nuclear Power Plant

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1. Introduction

The input seismic load is an important factor when performing an analysis on the earthquake response of a structure. Ground motion observed during an earthquake is affected by the source effect, the propagation effect from the hypocenter, and the site effect. Therefore, when determining the input ground motion, it is necessary to consider these characteristics and determine the appropriate data.

Although the location is relatively close, ground motion observed within the same site causes a difference in phase and amplitude in the time history depending on the observation location, which is called a spatial variation of ground motion [1]. In general, in the dynamic analysis of structures for earthquakes, it is assumed that the foundation of the structure is subjected to the same ground motion uniformly [2]. However, spatial variation has a significant impact on the response to earthquakes of large structures such as bridges and pipelines that extend parallel to the ground surface [3].

Therefore, for the assessment of seismic safety, it is necessary to consider the spatial variation of ground motion according to location. In this study, the spatial variation of ground motion was investigated using the earthquake records at the Hamaoka Nuclear Power Plant in Japan.

2. Recorded ground motion data

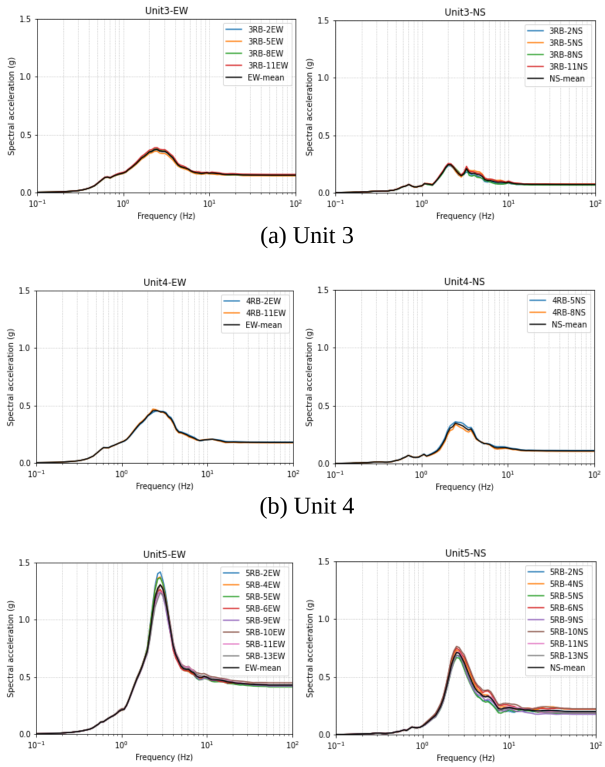
In the case of Korea, since there are insufficient records of earthquakes observed from nuclear power plants, studies have been conducted using the data of strong earthquakes in Japan [4].

In this study, ground motion data from the Hamaoka Nuclear Power Plant for the 2009 Suruga Bay earthquake observed by Chubu Electric Power were purchased and utilized from the Japan Association for Earthquake Engineers (JAEE) [5].

Most strong earthquake records are observed on the basement floor of the structure or on the ground surface, so the data recorded at these locations are closely related to the design earthquake input motions [6]. Therefore, in this study, the observed records at the basement floor layer of the structure and the ground surface were used.

3. Spatial variation of observed data from structures

Due to the spatial variability of seismic waves, different responses are shown depending on the observation location even if they are located on the same layer within one reactor building.



(a) Unit 3

(b) Unit 4

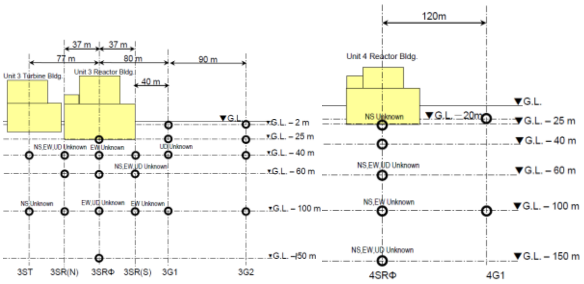
(c) Unit 5

Fig. 1. Response spectra of basement floor for each unit.

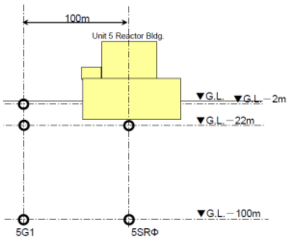
Fig. 1 shows the acceleration response spectrum of the basement floor for each unit. In the case of unit 3 and unit 4, there was a difference in spectral acceleration of up to 0.05 g, in the case of unit 5, there was a difference of 0.22 g in the east-west direction and 0.13 g in the north-south direction.

4. Comparison of response between the basement of the structure and the free field surface

By comparing the response of the structure and the ground, the change in the response spectrum of the ground motion according to the location was analyzed. For the response of the structure, the data of the basement floor was used. For the response of the ground, boreholes data for two depths corresponding to the maximum depth of 25 m below the maximum depth for each unit were used. Fig. 2 shows the borehole observation information of the Hamaoka Nuclear Power Plant.

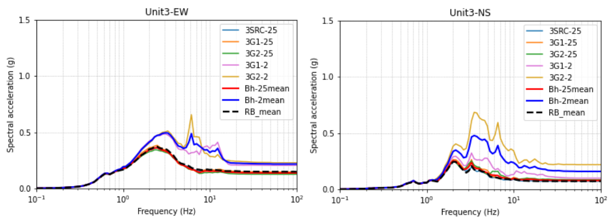


(a) Unit 3 (b) Unit 4

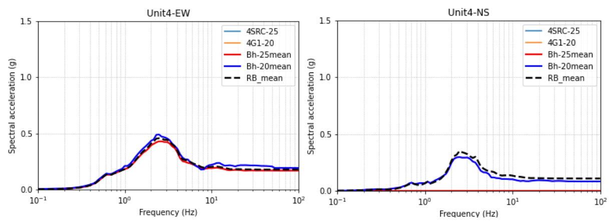


(c) Unit 5

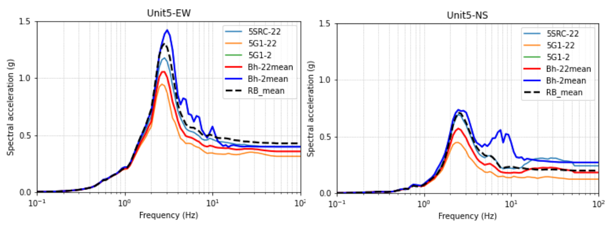
Fig. 2. South-North cross sectional view for each unit



(a) Unit 3



(b) Unit 4



(c) Unit5

Fig. 3. Response spectra of free field surface for each unit.

As shown in Fig. 3, in the case of unit 4, the basement of the structure and the free field response were similar. In unit 3 and unit 5, there was a difference in response of 0.3 g up to 0.4 g in two boreholes located at a close distance. In addition, the difference between the average of the structure basement and the average of the free field response in the two units was more than 0.3 g. Through these analysis results, it was confirmed that even if the same earthquake was experienced, the response was different due to various factors such as the observed location, relative location with the hypocenter, depth, and the soil-structure interaction.

5. Conclusions

In this study, the spatial variation of the ground motion according to the location was analyzed using the observed records of the structure of nuclear power plant and the site borehole.

The difference in spectral acceleration occurred at a maximum of 0.22 g within the structure, at a maximum of 0.4 g at the borehole, and at a maximum of 0.3 g at the average of the structure basement and the surface.

Such spatial variability of ground motion affects the response of structures. Therefore, more systematic research and review are needed for the seismic safety assessment.

Acknowledgement

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