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Generation of Artificial Earthquake Time Histories for a Research Reactor

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1. Introduction

A Reactor Structure Assembly(RSA) is fixed to the floor with bolts. The research reactor can be subjected to floor accelerations through a building from the ground accelerations during an earthquake. The research reactor must design to withstand the floor acceleration response spectra provided by the results of seismic analysis for the reactor building. The artificial time histories(ATH) are generated compatible with the enveloped seismic input of Floor Response Spectra(FRS) in East-West(EW), North-South(NS), and Vertical(VT) directions.

2. Methods and Results

2.1 Description

The research reactor is supported by the embedment plate of the floor as shown in Fig. 1. The bottom plate of RSA is bolted into an embedment plate using fix bolts.

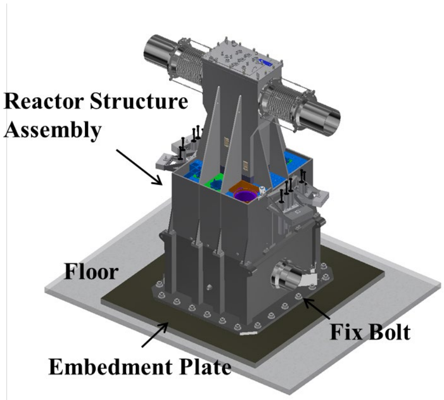


Fig. 1. Research reactor

The design ground response spectra at horizontal and vertical directions are developed based on the standard response spectra specified in KEPIC STB 2.2.3[1] as well as USNRC 1.60[2]. The floor accelerations through the reactor building from the design ground accelerations should be applied to the research reactor. Therefore, FRS in three directions at the reactor location are generated following USNRC 1.122[3] by time history analyses of the building.

2.2 Generation of Artificial Time Histories(ATH)

Three directional ATH as shown in Fig. 2(EW direction only) are generated using P-CARES[4]. The red line on the left side of the figure represents the FRS at the reactor location, and the blue line shows the response spectrum of the generated time history data. A 5% damping ratio of FRS at the SSE level is selected as the target response spectrum. The ground velocity and displacement are forced to be zero at the end of the motion using the baseline correction algorithm[4].

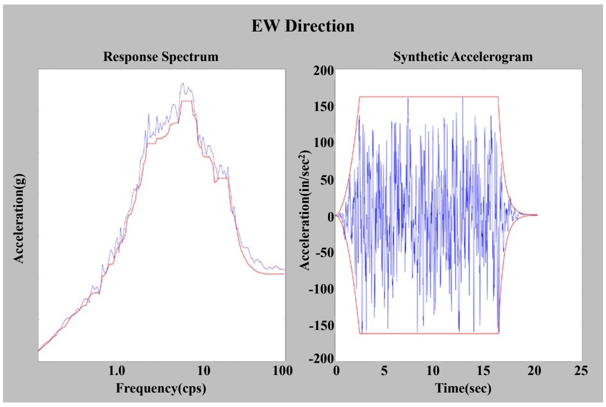


Fig. 2. Artificial earthquake time histories

2.3 Code Verification of Generated ATH

NUREG-0800[5] requires each pair of ATH to be statistically independent with a correlation coefficient of less than 0.16. Table I shows the calculated correlation coefficients that satisfy the code requirements.

Table I: Correlation coefficient

Direction	EW	NS	VT
EW	-	0.04	0.01
NS	0.04	-	0.01
VT	0.01	0.01	-

The strong motion duration is defined by Arias Intensity(AI), which covers 5% to 75% of the total cumulative energy[5]. This energy can be calculated as[6]:

$$I_{Arias} = \frac{\pi}{2g}\int_0^T a(t)^2\, dt$$

Fig. 3 shows cumulative AI curves with indications of 5% and 75% AIs for each direction, and the strong motion duration meets the minimum requirement of six seconds as shown in Table II.

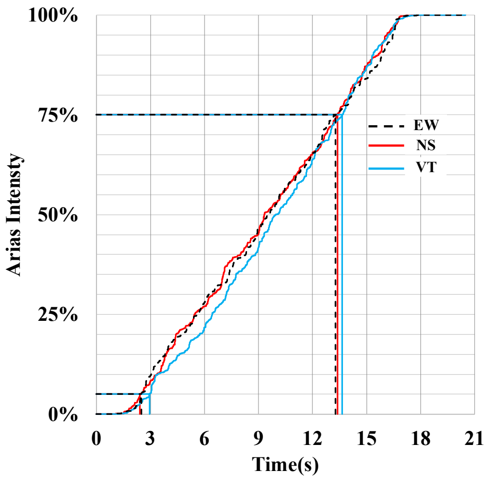


Fig. 3. Cumulative Arias Intensity(AI)

Table II: Arias Intensity(AI) for time histories

Direction	5% AI(s)	75% AI(s)	Strong duration(s)
EW	2.512	13.286	10.775
NS	2.428	13.381	10.953
VT	2.947	13.656	10.710

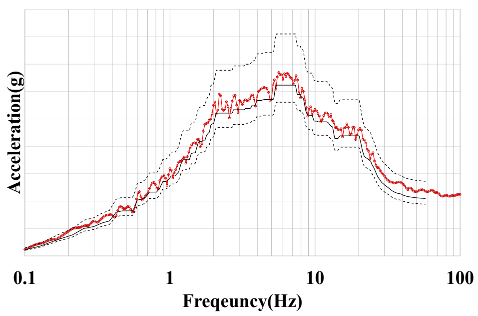
The generated ATH also satisfies the NUREG-0800 Approach 2[5] as follows:

(a) Used the time increment of 0.005 seconds considering the Nyquist frequency of 100 Hz and the total duration of 20.48 seconds.

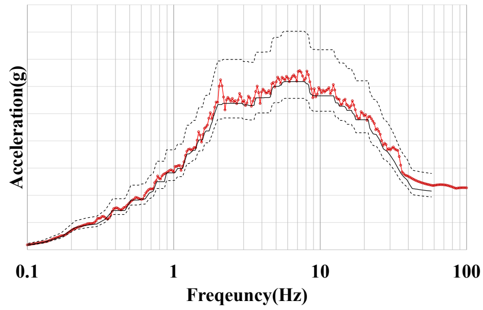
(b) Used spectral acceleration at the 5% damping ratio to compute at least 100 points per frequency decade(evenly spaced from 0.1 Hz to 100 Hz on the log frequency scale).

(c) Did not fall more than 10% acceleration response spectrum below the target response spectrum at any one frequency point and more than nine adjacent frequency points below the target response spectrum.

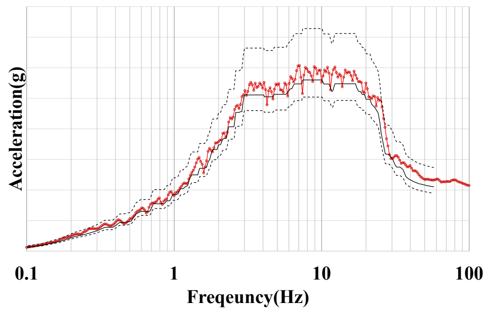
(d) Did not exceed the target response spectrum at any frequency point by more than 30% in the interest frequency range.



(a) East-West(EW) direction



(b) North-South(NS) direction



(c) Vertical(VT) direction

Fig. 4. Code verification of generated ATH

3. Conclusions

In this study, artificial earthquake time histories at the location of the research reactor are generated with the satisfaction of the code requirements. These time history data will be used to perform time history analyses to check the structural integrity of the reactor as well as design safety requirements of the components such as displacement limit for the reflectors.

ACKNOWLEDGEMENTS

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