

Strong Ground Motion Simulation at WSN seismic station Considering 2016 Gyeongju Earthquake

Hoseon Choi ^{a*}

^aKorea Institute of Nuclear Safety, 62 Gwakk-ro, Yuseong-gu, Daejeon 34142

*Corresponding author: hoseon@kins.re.kr

1. Introduction

2016 Gyeongju earthquake with local magnitude (M_L) 5.8 or moment magnitude (M_W) 5.5 (mainshock), the largest one since Korea Meteorological Administration (KMA) started its formal earthquake reporting around the Korean Peninsula in 1978, has raised public anxiety for the safety of major facilities like nuclear power plants against earthquakes. In this study, strong ground motions at WSN seismic station by a scenario earthquake on the causative fault of 2016 Gyeongju earthquake are simulated by using stochastic and empirical Green's function (EGF) methods, and are indirectly compared with standard design response spectrum of RG 1.60 [1] (anchored to 0.3 g) at the site. WSN seismic station has been operated by Korea Institute of Nuclear Safety (KINS) since 1998 and is located within Wolsong nuclear power plant site.

2. Methods and Results

2.1 Stochastic Method

The stochastic method is proposed to predict strong ground motions based on that high frequency acceleration time histories can be modeled using white Gaussian noise with finite duration [2,3]. The amplitude spectrum model consists of seismic source, path, and site characteristics. In this study, a ratio of spectral amplitudes of observed and simulated waveforms for the mainshock is simply assumed to be an adjustment factor. The EXSIM code is used for strong ground motion simulation by the stochastic method [4]. Given that the moment magnitude of the scenario earthquake is 6.5 and the ratio of its causative fault length and width is 2:1, simulated waveforms and response spectra at WSN seismic station are presented in Fig. 1.

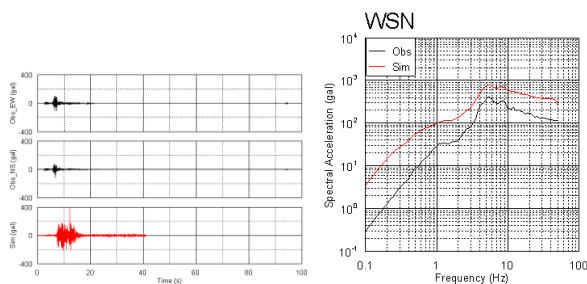


Fig. 1. Observed (black solid line) and simulated (red solid line) waveforms and their response spectra. Observed

waveforms and response spectra are for the mainshock, and simulated waveforms and response spectra are by the stochastic method with the consideration of an adjustment factor for the scenario earthquake. The response spectrum for the mainshock is given as the root mean square (RMS) of two horizontal components.

2.2 EGF Method

If two different-sized earthquakes occurred at a same fault were recorded at a same seismic station, they would eventually share path and site characteristics. Therefore, if a relative adjustment of their seismic sources is well conducted, observed ground motions of a smaller earthquake can be used as a Green's function for a larger earthquake that occurred on the same fault. The observed ground motions that can be used as a Green's function is called the empirical Green's function (EGF) [5] and the EGF code is used for strong ground motion simulation by the EGF method [6]. Simulated ground motions of the scenario earthquake by assuming that ground motions by the mainshock are EGFs, with east-west and north-south components are presented in Fig. 2.

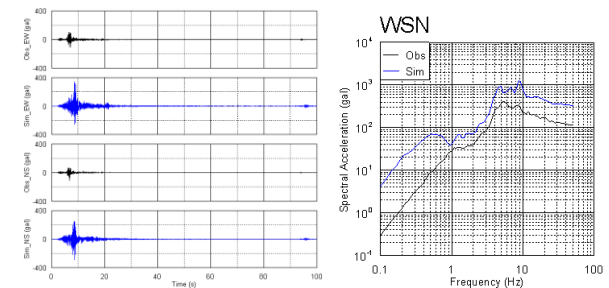


Fig. 2. Observed (black solid line) and simulated (blue solid line) waveforms and response spectra. Observed waveforms and response spectra are for the mainshock, and simulated waveforms and response spectra are by the EGF method for the scenario earthquake. The Response spectra for the mainshock and scenario earthquake are given as the root mean square (RMS) of two horizontal components.

2.3 Comparison of Simulation Results

Fig. 3 shows comparisons of response spectra by the stochastic method with the consideration of an adjustment factor and the EGF method for the scenario earthquake. Overall, two response spectra at WSN seismic station are similar to each other. Although the ratio of simulated spectral amplitudes by two methods varies by frequency, it is about 1.115 times on average,

with slightly larger amplitudes by the stochastic method. Simulated waveforms by the stochastic method show weak deficiencies of spectral amplitude in intermediate frequency. Fig. 3 also shows horizontal standard design response spectra of RG 1.60 [1] (anchored to 0.3 g). Simulated response spectra at WSN seismic station by two methods are found to exceed slightly RG 1.60 response spectra in a frequency band above 4 Hz, but considerable attention to interpretation is required since the assumed input data was used.

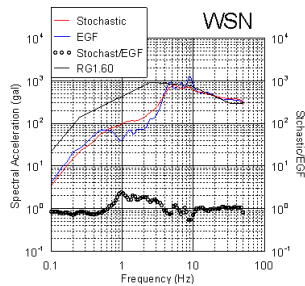


Fig. 3. Simulated response spectra by the stochastic method (red solid line) and EGF method (blue solid line). The ratios of response spectra are depicted in black circle. Horizontal standard design response spectrum of RG 1.60 [1] anchored to 0.3 g is also depicted in black solid line.

2.4 Comparison with Ground Motion Model

Peak ground accelerations (PGAs) by recently developed ground motion model (GMM) in South Korea [7] substituting the magnitude ($M_w 6.5$) and epicentral distance (25.7 km) between the seismic source to WSN seismic station, are compared with those by strong ground motion simulations. Fig. 4 shows the results of comparing PGA of observed ground motions with that of simulated ground motions by two methods. PGAs by two methods are estimated to be located at the bottom of PGA ranges by GMM. This may be due to a deviation from extrapolating to a large earthquake that far exceeds the local magnitude range used to develop GMM.

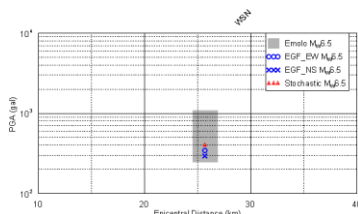


Fig. 4. Comparison between PGAs by the stochastic method (red triangle) and by EGF method with EW (blue circle) and NS (blue x) components for $M_w 6.5$ earthquake, and PGA range by GMPE (grey box) with $M_w 6.5$ earthquake

The stochastic and EGF methods are preliminary applied to simulate strong ground motions at WSN seismic stations within Wolsong nuclear power plant site by an assumed large scenario earthquake with $M_w 6.5$ on the causative fault of 2016 Gyeongju earthquake with $M_w 5.5$. Simulated response spectra by two methods have been found to exceed commonly standard design response spectra anchored at 0.3 g of the site slightly in a frequency band above 4 Hz, but considerable attention to interpretation is required since the assumed input data was used.

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3. Conclusions